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FORT HOOD GEOGRAPHIC INFORMATION SYSTEM: PILOT SYSTEM
DEVELOPMENT AND USE. (U) CONSTRUCTION ENGINEERING
RESEARCH LAB (ARMY) CHAMPAIGN IL W D GORAN ET AL.

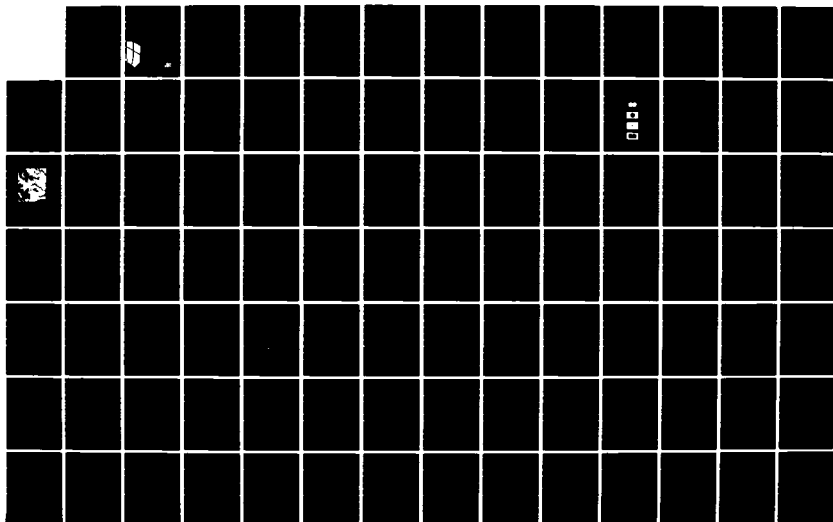
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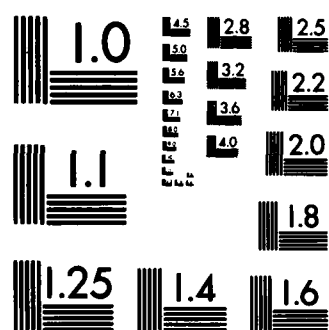
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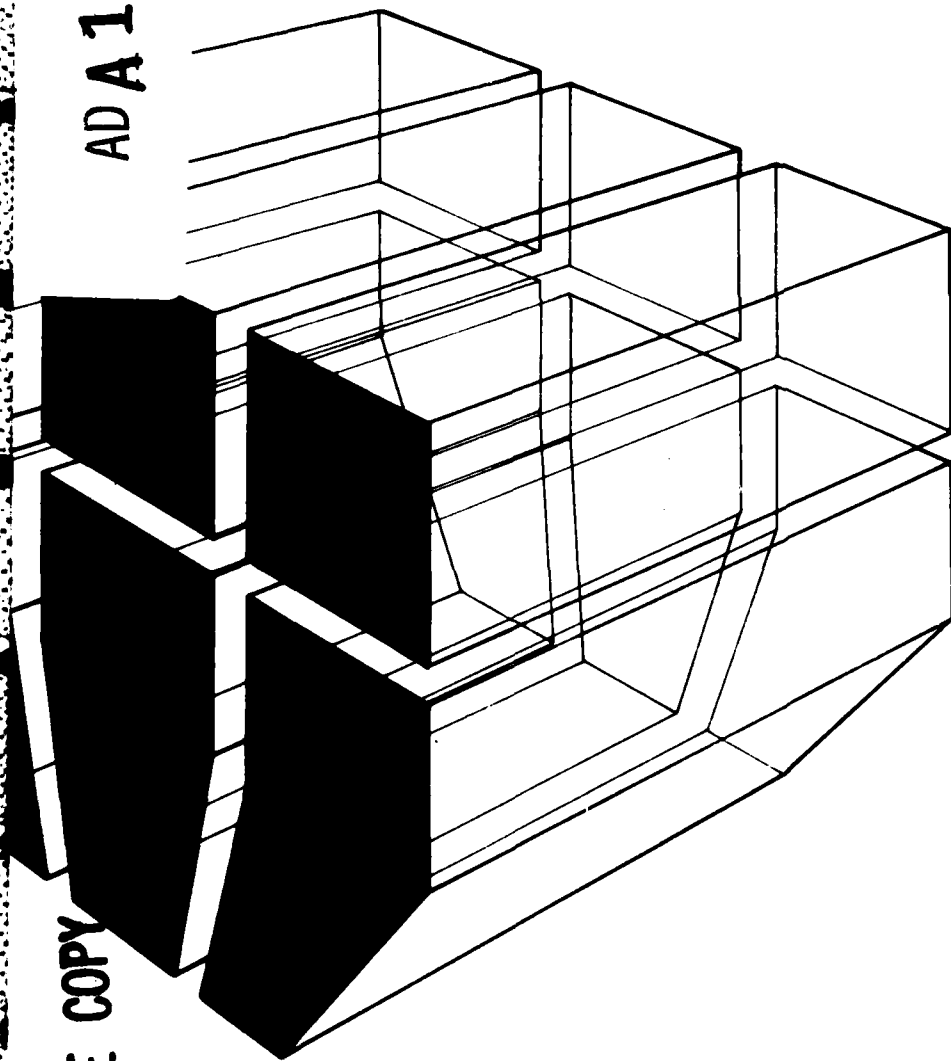
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**FORT HOOD GEOGRAPHIC INFORMATION SYSTEM:
PILOT SYSTEM DEVELOPMENT AND USER INSTRUCTIONS**

by
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Lloyd Van Warren
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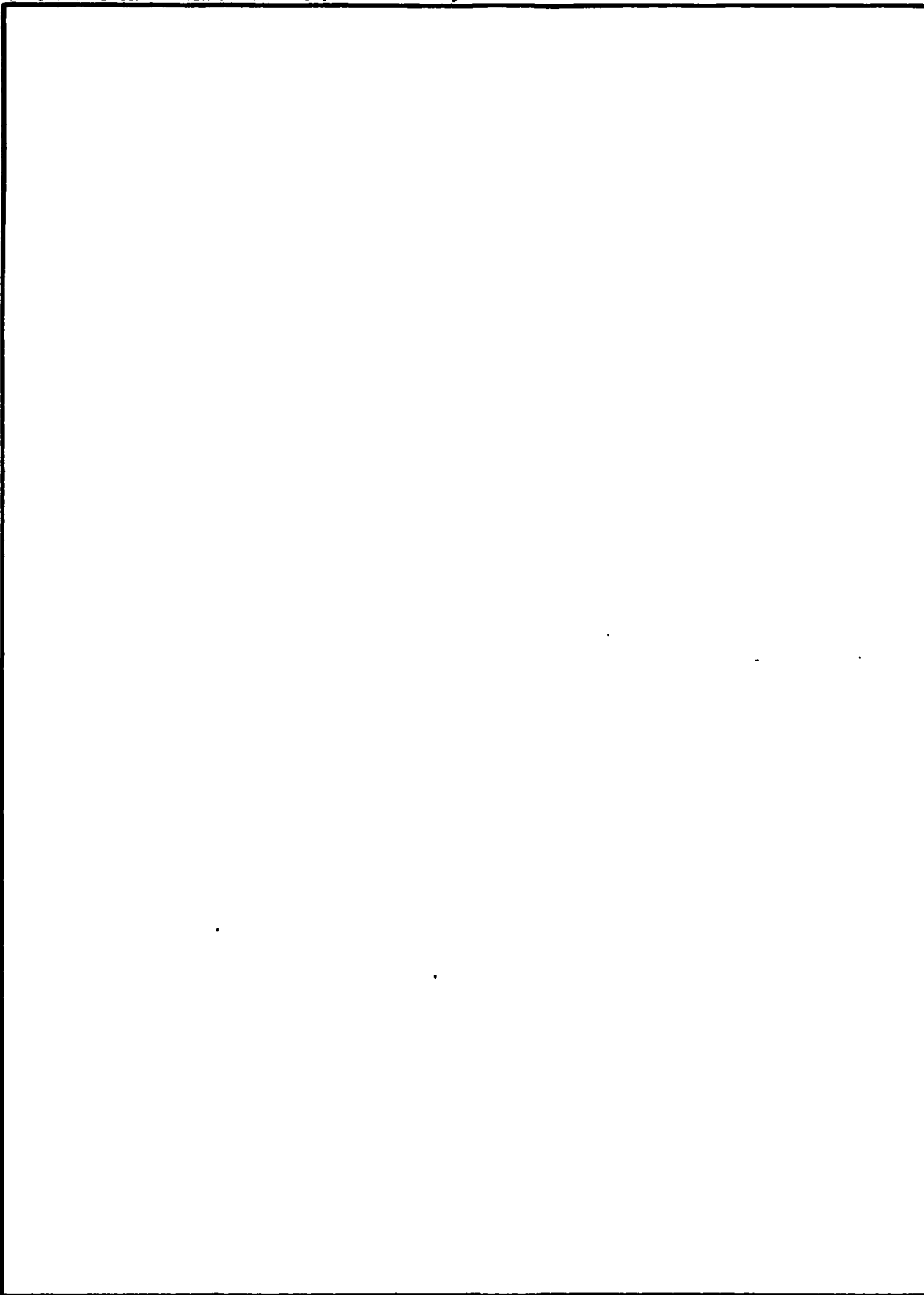
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FOREWORD

This research was conducted for the Fort Hood Environmental Programs Office, Fort Hood, TX, under Research Intra-Agency Order 330-80, dated 25 July 1980. The Fort Hood Technical Monitors were Mr. David Palmer, Mr. Raymond Leone, Ms. Karen Evans, and Mr. William Bodkin (all of AFZE-FE).

The work was performed by the Environmental Division (EN) of the U.S. Army Construction Engineering Research Laboratory (CERL). Dr. R. K. Jain is Chief of CERL-EN. Appreciation is expressed to Dr. F. Briuer (Fort Hood), Mr. James Westervelt of CERL, who helped design and develop this system, and to the following personnel of the University of Illinois: Dr. Thomas Frank, who worked with the Landsat data; Ms. Mary Catherine Jones, who prepared and digitized much of the data; and Mr. Daniel Goriesky, who developed the Information System.

COL Louis J. Circeo is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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FORT HOOD GEOGRAPHIC INFORMATION SYSTEM:
PILOT SYSTEM DEVELOPMENT AND USER INSTRUCTIONS

1 INTRODUCTION

Background

The Environmental Technical Information System (ETIS) was developed by the U.S. Army Construction Engineering Research Laboratory (CERL) to help installation-level military personnel meet the planning and documentation requirements of the National Environmental Policy Act and related Army requirements.¹ The Environmental Programs Office at Fort Hood, TX -- a frequent, supportive user of ETIS -- asked CERL to modify ETIS output to make it site-specific to that installation. CERL then developed a pilot system to determine if ETIS output could be modified to serve as a geographic information system specific to the environmental planning, evaluation, and documentation needs of the Fort Hood Environmental Programs Office.

Objective

The objective of this report is to describe and evaluate the requirements for an ETIS pilot geographic information system that incorporates existing environmental information on Fort Hood, including natural resource, remote sensing, and training use data, as well as other environmental planning information.

Approach

The general approach to this study included the following steps:

1. Develop a geographic referencing scheme.
2. Load Fort Hood data into the geographic referencing scheme.
3. Evaluate the hardware and software for the Fort Hood/ETIS pilot system.

In addition, the development approach considered the following specific needs of the Fort Hood Environmental Programs Office:

¹ R. D. Webster, R. L. Welsh, and R. K. Jain, Development of the Environmental Technical Information System, Interim Report E-52/ADA009668 (U.S. Army Construction Engineering Research Laboratory [CERL], April 1975); National Environmental Policy Act of 1969, PL Stat 852, 42 USC 4321, et seq. (January 1970); and Environmental Protection and Enhancement, Army Regulation (AR) 200-1 (Department of the Army, February 1974).

1. Minimal hardware and software requirements.
2. Multivariant, interdisciplinary searching, manipulation, and display of necessary information.
3. Ease of use and consistency with the ETIS conceptual framework.

2 GEOGRAPHIC DATABASE -- CONCEPT DESCRIPTION

Environmental planners must have access to accurate data if they are to reliably analyze ongoing programs and proposed activities. Although environmental data are, by nature, very cumbersome and location-oriented, a geographic digital database allows large amounts of information registered to specific locations to be stored, accessed, displayed, and manipulated quickly and accurately.

Data entered into such a database can be listed under three basic classes: point, line, and area. *Point data* are information that can be cartographically represented as a single point; e.g., well sites, towers, or other structures whose locations have no area significance. *Line data* are linear features such as roads or pipelines. *Area data*, the most common data type, are features such as soil type, plant cover, elevation zones, slope categories, and other continuous surface coverage items.

The most common method of entering geographic information into a geographic digital database is to partition a given area on the earth's surface into cells. These cells can be organized on a coordinate system, such as the Universal Transverse Mercator (UTM) system, to form a grid network. Each grid cell represents a square unit of land. This grid can have multiple layers, with each layer representing a separate type of information. For example, one layer could be land cover type, while another could be soil series type. A computer can use this grid system to sort geographic information quickly to find specific areas. Information about those specific areas can then be displayed in tables, maps, or columnar files.

Before a study area is divided into grid cells, the size of each cell must be considered carefully. If the grid size is not well chosen, its information can be under- or over-generalized. When information is under-generalized, the database becomes too large for the computer to sort and store efficiently, slowing data access and manipulation. If the grid cells represent too much area, the data are over-generalized, and much information is lost. Thus, the grid cell area must be large enough to insure adequate information for analysis, but small enough to be handled efficiently by the computer.

Most data entered into a geographic database are originally in map form. The mapped area is overlaid with a grid, and the information in each grid cell is entered into the computer. For example, if vegetation data are required for the database, a vegetation map is overlaid with a grid. Each grid cell is addressed by a reference system referring to its row and column location in the grid. The vegetation type is then encoded into the database. However, this process can make data entry tedious and difficult.

The data entry process can be simplified by using a machine known as a digitizer. The digitizer has a cursor which can be activated at points or along lines on a map. If provided with a mapping scale and known reference points, the digitizer will automatically compute the grid row and column location for all single or connected points (lines) identified by the cursor. Areas on maps can be defined by moving the cursor along their perimeter. These digitized perimeter lines can be converted to grid area data through a

program which "fills" the grid cells occurring within defined perimeters. These files are then read into the data structure of the geographic information system.

After the database is developed, different programs can be written to perform the data analysis. These analyses can include retrieving specific variable locations, calculating areas, combining variables, weighting variables in combinations, and calculating distances from specified points.

3 SYSTEM OVERVIEW

Overall System Concept

The Fort Hood/ETIS pilot system offers an extremely fast and efficient way to combine the geographic attributes of the Fort Hood database. Conceptually, the database can be viewed as a stack of checkerboard-type grid cell maps. Each cell is associated with a 100- x 100-meter-square area. In this stack of "checkerboards," the top board represents a specific area type, such as vegetation. Each cell is assigned a code which corresponds to the dominant vegetation type within that 100-meter-square cell. The second board represents another specific area type, such as current land use. Each cell on this board represents exactly the same area as the cell directly above (or below) it on the other boards.

One way to visualize the database structure is to imagine standing directly above a set of stacked boards looking at the corner cell. If all of the boards were clear and marked with appropriate codes, it would be possible to see several of the corner cell's characteristics. Obviously, with a stack of more than a few such boards, the amount of information that could be seen when looking through the stack would be overwhelming, and lower boards would not be visible. The Fort Hood/ETIS pilot system allows the user to sort through all of these boards, select and combine whatever boards (or layers) are desired, and access these data using system-specific instructions.

A user can approach the system in two ways:

1. The user has a specific area of interest and wants to identify the location and extent of certain features, or combinations of features, within that area (see Appendix C).
2. The user has specific features, or combinations of features, required for a particular land use activity and wants to find them wherever they occur in the database (or within a specified area).

For either approach, the user's first system operation is to identify his* area of interest. If the user is primarily interested in locating specific features, rather than specific areas, he can either choose to search the entire database, or he can run the program more than once, searching smaller areas, or "windows," within the database. In general, the computer can search small windows more quickly and efficiently than large windows.

System Operation

After the user answers some initial questions, the basic design flow is as follows:

* The male pronoun is used throughout this report to refer to both genders.

Step 1. The user defines his area of interest.

Step 2.

a. The user makes major category (primary) choice.

b. The user makes subcategory (secondary) choices.

Step 3. The system searches the database and creates a mask* for each subcategory choice and then prints the user table.

Step 4.

a. The user chooses one of five main options.

b. The user chooses suboptions from within the main option selected.

When a user first enters the system, he is asked three initial questions. These questions "set up" the system for that particular session. These questions are:

Noise protection on? (yes or no):**

Full prompting on? (yes or no):

Are you on a video terminal? (yes or no):

Noise Protection (yes or no):

The option of noise protection has been provided for users who experience interference, or noise, in telephone line transmission. This has been a particularly vexing problem at Fort Hood. If a user responds "yes" to this question, then transmission of maps cannot be interrupted -- either by noise or by the user. This allows processes which require relatively large time intervals to continue without interruption. However, this special protection is not provided during steps that require user input.

Full Prompting On? (yes or no):

The second question lets the user set the pace at which a session proceeds. With a "y" response, the user is prompted through each step in the session, and the data table is reprinted automatically after a new item is added. With an "n" response, choices are not displayed. The user is simply asked:

* A "mask" is a map with all unit cells classified as either "zeroes" or "ones." Essentially, a "mask" identifies the area of interest with "ones," and "masks out" all other information with "zeroes."

**For all yes/no responses, a lower case "y" or "n" is sufficient.

area method >,
main choices >,
secondary choices >,
options >

In either mode -- verbose (full prompting) or nonverbose -- the user can ask for help by typing "?". The system will respond by displaying a helpfile. In the nonverbose mode, the user can ask for a choice list by hitting the return key three times. The system will respond by displaying the choice lists available in the verbose mode.

Are You on a Video Terminal (yes or no):

The user's response to the third question tells the system whether the user's machine has an addressable cursor. (If in doubt, the user should answer "n.") At present, a "y" response only affects display procedures in some choices of Step 1. In the future, more video capabilities may be implemented.

If the user answers "yes," he must first have told the operating system what type of video terminal he is on so the system can adjust to that type of video cursor. For example, if the user is on a VT100, the cursor command is "TERM=dl;exportTERM." This command is given before the user enters the geographic information system. A listing of commands is provided for most types of terminals in the file "Termcap."

Step 1

In this step, the user tells the system what part of the geographic database he wants to study. The system asks how you want to specify your working area and offers six options:

1. UTM coordinates
2. Array coordinates
3. Predetermined area (3 x 3)
4. Predetermined area (4 x 5)
5. One-kilometer square
6. Entire database.

The user's working area must be a square or rectangle* and must be within database limits. Figure 1 gives the dimensions of the database.

Option 1

With Option 1, a user defines a working area (or window) with coordinates from the UTM geographic grid.** Once this option is selected, the program asks the user to input a six-digit coordinate to define

lower-left PK:

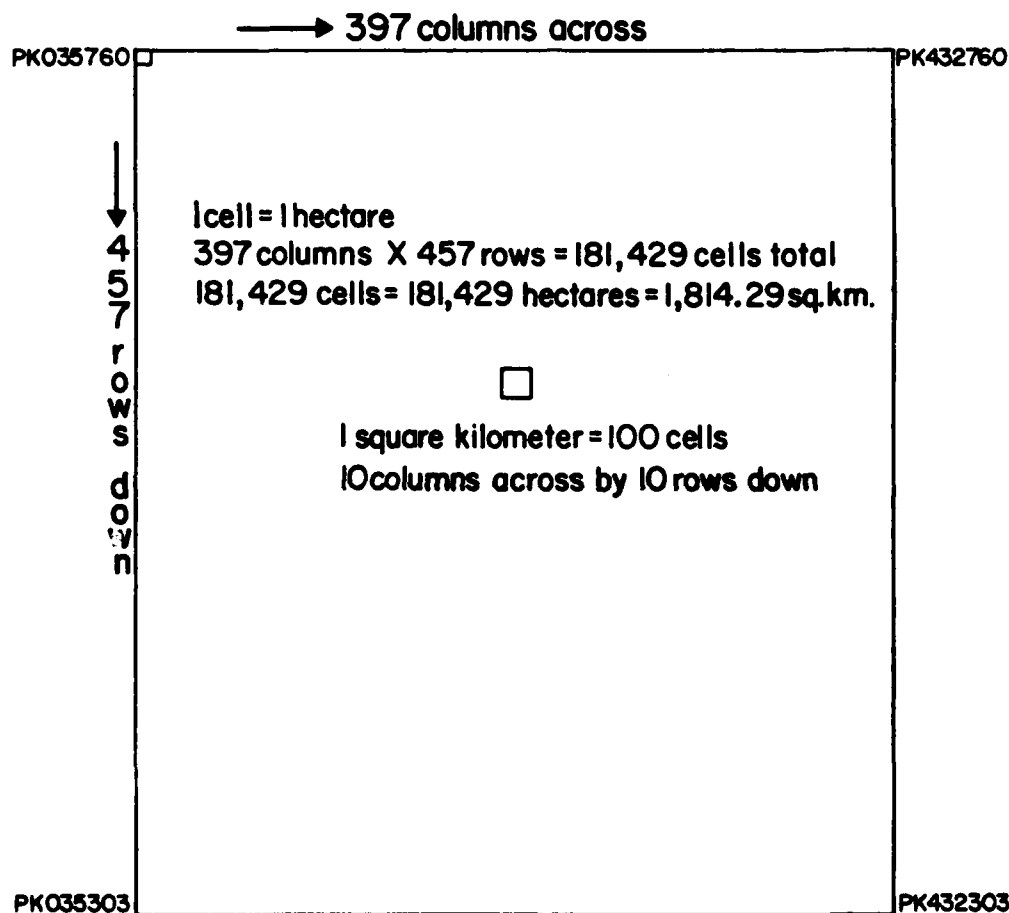


Figure 1. Database dimensions.

* A revised version of this management information system is currently being developed. This new version will allow users to define nonrectangular working areas.

**The entire Fort Hood database occurs within the UTM grid designated with the letters PK. Thus, to shorten the user's response, "PK" is printed by the system and only the six-digit numerical designation is required.

This UTM coordinate must be read first as a three-digit, east-west designation, then as a three-digit, north-south designation. This establishes the southwest corner of the rectangle. Next, the user is asked to define

upper right PK:

This establishes the northeast corner of the rectangle. The rectangular working area is created from these two corners.

In UTM coordinates, the boundaries of the database extend from west (PK035) to east (PK432), and from south (PK303) to north (PK760). The coordinates given for the upper-right corner should be greater than those for the lower-left corner in both the east-west and the north-south dimensions. To define a working area with the UTM coordinate method, the user should first consult a Fort Hood map on which this grid system is printed. Figure 2 is an example of a UTM coordinate window selection, and the resulting output from the system.

Option 2

Option 2 lets the user define any size of rectangle, using array coordinates. With array coordinates, grid cells are counted by columns (running north-south) and rows (running east-west). Row 1, Column 1, is the northwest cell. All other cells are referenced by the number of cell rows down from the north and the number of cell columns across from the west; e.g., like text is read across and down a page. In all, there are 457 one-hectare rows north-south (UTM 760 to UTM 303), and 397 one-hectare columns east-west (UTM 035 to UTM 432). To define a working area by array coordinates, the user responds to four separate queries:

first row:

last row:

first column:

last column:

A working area can be only one column deep or wide. Thus, the last row equals the first row, or the last column equals the first column. The last row must not be smaller than the first row, and the last column must not be smaller than the first column. Within this limitation, all responses between Rows 1 and 457 and Columns 1 and 397 are acceptable.

Options 3 and 4

These options let users quickly define working areas without specifying either UTM or array coordinates. Option 3's sectors are just a little more than 200 kilometers square, with the three sectors in the central column being slightly larger. Option 4's sectors are much smaller, since they were designed to divide the database into 100-kilometer squares. However, all perimeter sections are slightly larger or smaller, and the top tiers of sections 1 through 4 are only 60 kilometers square.

How do you want to specify your working area? :

- | | |
|----------------------------|----------------------------|
| 1) UTM coordinates | 2) Array coordinates |
| 3) Predefined area (3 x 3) | 4) Predefined area (5 x 4) |
| 5) 1 kilometer square | 6) Entire installation |

Select options by number separated by spaces, or type ? for more detail.

--> "1"

lower left PK: "280460"
upper right PK: "432610"

```
=====
Selected region has an area of 228.000 square kilometers.
Corners: lower left PK: 280460 upper right PK: 432610
Array coords: 1st row: 151 Nth row: 300 1st col: 246 Nth col: 397
This area will be referred to as window A.
=====
```

Satisfied with selected area: "y"

NOTE: User input is inside quotes.

Figure 2. UTM window selection.

When a user chooses either Option 3 or Option 4, a small diagram of the database is displayed, indicating the coordinates and location of the various sectors. The chosen sector is then highlighted. Figure 3 is an example of output from the 4 x 5 predefined area selection.

Option 5

Option 5 defines a single-kilometer working area when the user inputs a four-digit UTM coordinate. This coordinate (read as two east-west digits and then two north-south digits) describes a 100-hectare area (10 cells north-south by 10 cells east-west). This area is defined by the lower-left (south-west) corner. Thus, to request the 1-kilometer square between PK 240 490 and PK 250 500, the user would respond to the query "Lower-left PK:" with 2449.

Option 6

Option 6 is a quick method of defining the entire database as the working area. This could also be done by using Option 1 or Option 2.

Steps 2a and 2b

These two steps are linked. Each primary choice represents a layer of the database, and each secondary choice represents a subcategory within that layer. The pilot system now has 30 primary choices (or layers), with numbers of subcategories in these layers varying from 95 (e.g., for training areas) to 1. Within each main category, each cell has a specific designation; a single cell can have only one subcategory designation.

Data table masks are created for each subcategory choice. (No masks are created for main category choices, because this step is only the first level in the data selection process.) The number of subcategory choices in a single user session is limited to 50. However, the speed of any particular session depends partly on the number of subcategories chosen, since the system has to search the working area and create a mask for each chosen item. Furthermore, for video uses, the size of the screen limits the number of items that can be viewed at one time on the user table. This limit is considerably less than 50. However, future adjustments to video options may eliminate this problem (e.g., some terminals allow for reductions in text size). Chapter 5 provides a detailed description of the database.

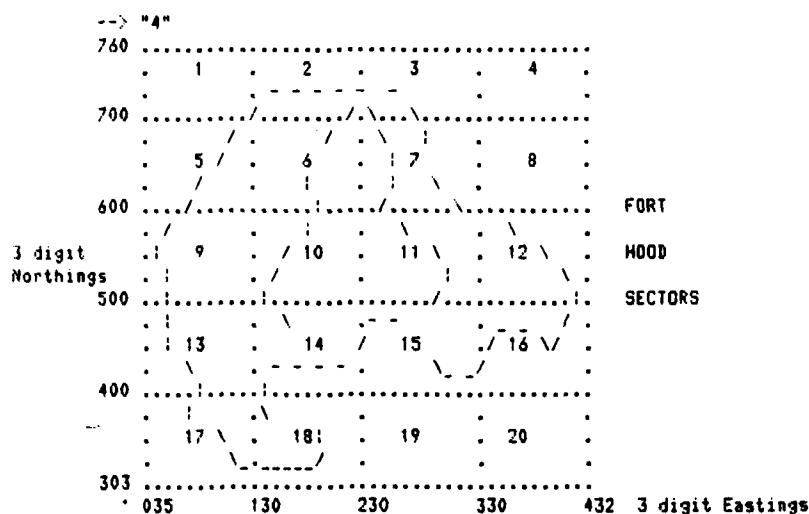
Step 3

After the data choices are made and the user indicates that he is satisfied with these choices, the system creates a bit map, or mask, for each subcategory. Figure 4 shows an example bit map. The time required for the system to generate a mask varies with the number of users and level of use of the entire Fort Hood/ETIS system (unless the pilot environmental management system is run as an independent machine). Although it takes only a few seconds to create each mask, mask-making can be the most time-consuming part of a user session.

How do you want to specify your working area? :

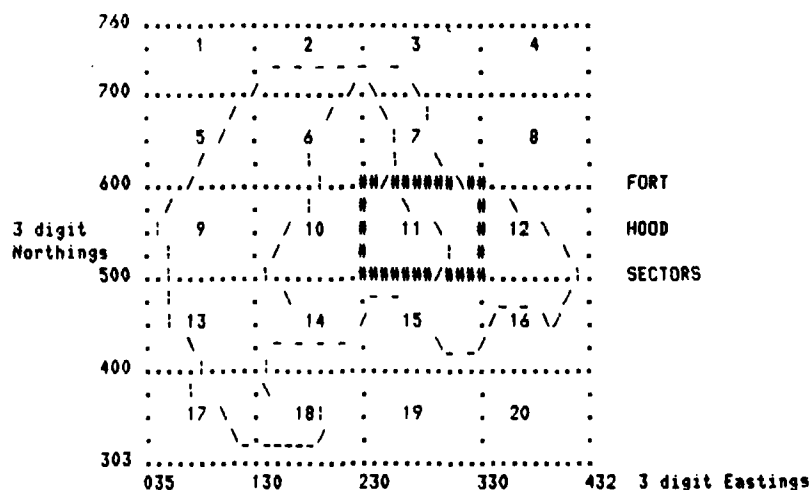
- 1) UTM coordinates 2) Array coordinates
- 3) Predefined area (3 x 3) 4) Predefined area (5 x 4)
- 5) 1 kilometer square 6) Entire installation

Select options by number separated by spaces, or type ? for more detail.



Specify one interest area by number [1-20]: "11"

You have chosen section 11.



```

=====
Selected region has an area of 100.000 square kilometers.
Corners: lower left PK: 230500 upper right PK: 330600
Array coords: 1st row: 161 Nth row: 260 1st col: 196 Nth col: 295
This area will be referred to as window A.
=====
Satisfied with selected area: "y"

```

Figure 3. 4 x 5 predefined area selection.

Creating mask 9.

```
.....
.....
.....))
.....
.....
```

Creating mask 10.

```
.....
.....
.....*
.....*
.....
```

Creating mask 11.

```
.....
.....
.....+
.....++
.....+++
.....
```

Creating mask 12.

```
.....
.....
.....
...../
...../
...../
```

Creating mask 13.

```
.....
.....
.....-
.....-
.....-
.....
```

Figure 4. Example bit map.

After the masks are made, the system constructs a user table. The table has an entry for each mask constructed (see sample in Figure 5). These tables have seven columns:

Column 1: (#) = table entry number. These numbers are used for all subsequent data manipulations.

Column 2: (windw) = window, or working area. Because more than one working area can be defined within a single user session, each working area is lettered sequentially (i.e., A, B, C, etc.). Each table entry is associated with a specific window.

#	undw	synd	catg.	item	area km.	% undw.
1	A	!	1.01	geol: limestn, dense	56.1	0.27
2	A	"	1.05	geol: shale, chalky	36.8	0.17
3	A	#	6.02	lcov: water	15.4	0.07
4	A	\$	6.03	lcov: forest	75.1	0.36
5	A	%	6.04	lcov: shrub	46.7	0.22
6	A	&	14.02	slope: 2 to 5%	85.1	0.40
7	A	'	14.03	slope: 5 to 10%	51.9	0.25
8	A	(	14.04	slope: 10 to 15%	16.3	0.08
9	A	)	17.01	trfq: 0 evnts/yr	13.2	0.06
10	A	*	17.02	trfq: < 100 evnts/yr	18.2	0.09
11	A	+	29.01	ends: golden-cheeked warbler	18.8	0.09
12	A	.	29.01	expr A: slot 1	10.9	0.05
13	A	-		Either 6 ! 7 OR both pres.	136.9	0.63
14	A			Both 4 & 8 pres.	8.9	0.04
15	A	/		Both 4 & 11 pres.	9.4	0.04

Figure 5. Example of user table.

Column 3: (synd.) = symbol. Each table entry is assigned a specific display symbol. The symbol represents this entry in the bit masks and in hardcopy displays.

Column 4: (catg.) = category of primary (before the decimal point) and secondary (after the decimal point) data choices that this item represents. New items created by overlay manipulations are listed as table entries but do not have a Column 4 category designation.

Column 5: (item) = brief description of the table entry. The primary choice is listed first, followed by a colon, which precedes the secondary choice (e.g., lcov: water).

Column 6: (area km²) = the area this item occupies in square kilometers. To convert this figure to square miles, acres, or hectares, the user can consult the statistics table.

Column 7: (% wndw.) = percent of the window (working area) occupied by this item.

Step 4

Once the data table has been constructed, the user is presented with several major options. These options include the analysis and display tools that comprise the heart of the management information system. From the main options table, the user chooses to overlay two or more data items, to display items from the data table, to display a particular type of table, or to go to an external subsystem. After each choice is completed, the user is returned to the main option table; the user exits the system from this level.

The options table has been broken down into two tiers; the main option level has the following five primary choices:

MAIN OPTION -->

(1) OPERATORS (2) TABLES (3) GRAPHICS (4) EXTERNALS (5) EXIT

1. Operators

The operators provide users with five different methods to overlay masks:

OPERATORS: 1) AND 2) OR 3) NOT 4) NOT AND 5) NOT OR

- 1) (AND) All cells where both A and B* occur.
- 2) (OR) All cells where either A or B occurs.
- 3) (NOT) All cells where A does not occur.
- 4) (NOT AND) All cells except where both A and B occur.
- 5) (NOT OR) All cells except where either A or B occurs.

Each of the operations creates a new item which is added to the data table, and this new item can then be recombined with any other item in the table. Combinations can be repeated as often as desired.

For the AND, OR, NOT AND, and NOT OR options, two items from the data tables are combined to create a new mask. With the NOT operator, only one data item is selected. The values of the cells in this data mask are then reversed, so that all cells where that item does not occur become positive (1) and all cells where that item does occur become negative (0). To complete this process, the system generates a new mask, and then adds a new item to the data table, just as in the other operations. A detailed explanation of these overlay operations is provided in the "Data Manipulation" Section of Chapter 4. Figure 6 also illustrates each of these five operations.

When a new mask is created, the system automatically assigns a new number and a new mapping symbol for this mask, and also calculates the mask's area. There is no limit to the number of masks that can be created in a single session; however, new masks can only be created from overlay combinations of masks already existing in the data table. Thus, the user must preselect, in Steps 2a and 2b, all of the data required for a particular session. Additional data cannot be retrieved for overlay operations unless the user begins an entire new session. Also, while there is no limit to the number of overlay operations in a single session, overlay operations can only be executed one at a time.**

2. Tables

Within this option, there are only two subchoices:

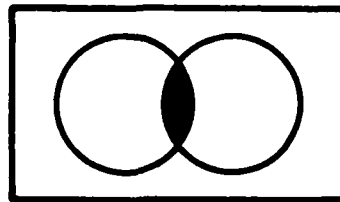
: 1) Table 2) Stats

Table (Subchoice 1) simply prints the regular data table as previously described (Step 3). This table is updated after each overlay operation; thus,

* A and B refer to the fact that the user is selecting items for manipulation.

**Both of the constraints (the requirements for preselection of data and execution of overlay operations one at a time) will be removed in the revised version of the system.

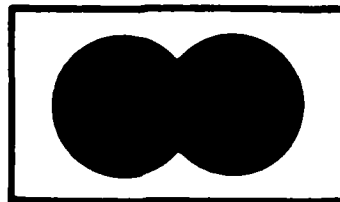
A "and" B
 $A \cap B$
 A Intersection B



Option 1

The AND Operation

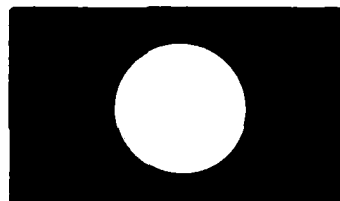
A "or" B
 $A \cup B$
 A Union B



Option 2

The OR Operation

Not A



Option 3

The NOT Operation

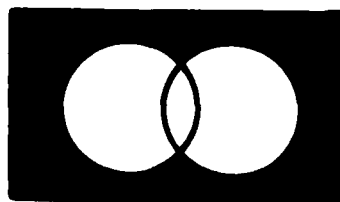
A "Not And" B
 $\text{Not } (A \cap B)$
 Not The Inter-
 section of A & B



Option 4

The NOT AND Operation

A "Not Or" B
 $\text{Not } (A \cup B)$
 Not The Union
 of A & B



Option 5

The NOT OR Operation

Figure 6. Venn diagram of set operations.

it may change frequently during a session. For users at workstations with both hardcopy and video devices, it is convenient to print out a paper copy of the original table, since user input from this table is necessary for subsequent overlay and graphic operations.

Stats (Option 2) prints area statistics for each item in the data table. These statistics include square kilometers, hectares, square miles, acres, percentage of working area, and percentage of the entire database. This table is also automatically updated each time a new item is added to the user table. However, to view this table, the user must enter the table's options and choose suboption 2. Figure 7 is an example of a statistics table.

3. Graphics

The graphics capabilities of this system vary with the type of output device. At present, there are options for a black-and-white video terminal, a color video terminal, a dot matrix black-and-white printer, and an all-purpose option that will drive any output device using alphanumeric symbols. These options are:

- 1) VT100 2) VT100 dump 3) Hardcopy 4) Ramtek 5) Dot Matrix

Options 1 and 2 operate on Digital Equipment Company (DEC) VT100 black-and-white video terminals. The first option displays items from the data table, as do options 3 and 4. Option 2, however, functions like Option 5. These "dump" all the items in a single primary data category. If, for example, a user wishes to see what soils occur in his area of interest, he would dump the soils data. Each different soil type would be assigned a different display category -- up to the number of available categories. At present, the Ramtek and hardcopy drivers do not provide this dump capability, and the dot matrix printer cannot yet display items from the data table. In the future, however, each of these output devices will have both capabilities.

Item	Net Area				percent sector	percent tot area
	sq. km.	hects.	sq. mi.	acres		
geol: limestn, dense	56.10	5610.0	21.63	13868	26.6	3.1
geol: shale, chalky	36.80	3680.0	14.19	9097	17.5	2.0
lcov: water	15.35	1535.0	5.92	3795	7.3	0.8
lcov: forest	75.07	7507.0	28.95	18557	35.6	4.1
lcov: shrub	46.68	4668.0	18.00	11539	22.2	2.6
slope: 2 to 5%	85.08	8508.0	32.81	21032	40.4	4.7
slope: 5 to 10%	51.87	5187.0	20.00	12822	24.6	2.9
slope: 10 to 15%	16.32	1632.0	6.29	4034	7.7	0.9
trfq: 0 evnts/yr	13.17	1317.0	5.08	3256	6.3	0.7
trfq: < 100 evnts/yr	18.22	1822.0	7.03	4504	8.7	1.0
ends: golden-cheeked wa	18.80	1880.0	7.25	4647	8.9	1.0
expr A: slot 1	10.93	1093.0	4.22	2702	5.2	0.6
Either 6 & 7 OR both pr	136.95	13695.0	52.81	33854	65.0	7.5
Both 4 & 8 pres.	8.50	850.0	3.28	2101	4.0	0.5
Both 4 & 11 pres.	9.38	938.0	3.62	2319	4.5	0.5

Figure 7. Example statistics table.

The dot matrix printer and the VT100 terminal automatically assign a black-and-white pattern (such as stripes or squares) to each displayed category, while, with the color Ramtek terminal, the user selects one of eight solid colors for each displayed category. With hardcopy display, the symbols assigned to each item in the data table are used to represent these items in map displays.

When a user chooses one of these display options, he is then asked a number of subsequent questions, which vary with each type of device. With hardcopy, the user is asked to choose the desired item for display from the data table; he is also given the following scale change option:

new row scale factor (was 9):

new column scale factor (was 4):

An increase in these numbers (e.g., 9 to 18, 4 to 8) reduces the size of the hardcopy display. The reverse is true if the numbers are decreased. Only whole numbers can be selected. If these numbers are not changed proportionately, the vertical/horizontal display ratio will be altered, and the map will be distorted.

With the Ramtek display, the user chooses the item of interest from the data table; then he is asked to choose one of seven colors: 0, black; 1, red; 2, green; 3, yellow; 4, blue; 5, magenta; 6, light blue; or 7, white. With the VT100, the user can choose types of black-white shading.

With either of these video displays, the user is also asked:

Do you want a reset?

If he responds "yes," the item will be displayed alone against a background grid. If he responds "no," the item will be displayed on the same screen as all other items displayed since the last reset. If two items occupy the same display space, the most recently displayed item will overprint the previous item.

This reset feature provides greatly enhanced display capabilities. Many items, if assigned different colors or different patterns, can be viewed in a single display. Also, several boundary features can be displayed to help reference other features, e.g., installation boundary, impact area boundary, major roads, railroads, county lines, or training area outlines. At present, hardcopy display does not have this capability, but this is a planned improvement.

A legend is provided with each display. This legend varies, depending on the display choice, but the following are always included (in some form):

1. Area of display in square kilometers
2. Area of one cell
3. Ratio of cells to display symbol or dots

4. Name and symbol of item(s) being displayed.

Figure 8 is an example of a dot matrix display with legend information.

4. Externals

The name "external" refers to programs that can be accessed from the main geographic information system, but are not an intrinsic part of that system. At present, there are three options:

1. Range
2. ASIS
3. Soils

Range. Range placement is a unique capability. A program called "range.place" is used to locate and "aim" firing ranges, so a particular range can be put at any location within the database and can be oriented to fire toward any compass direction. Until range data are placed with the range.place program, they are kept in the range data files, but are not placed in a fixed position in the actual database. Three ranges are now available: the XM-1 range, the dragon missile range, and the TOW missile range.

Through the range.place program, the user could, for example, place ranges around the periphery of the impact area, with each range firing into the impact area, to determine the best siting or the maximum capacity for this type of range. These ranges can then be overlaid with other features such as topography, vegetation, or soils to find sites with the most suitable placement characteristics.

The range.place program is easy to use. First, the user is asked:

what range?

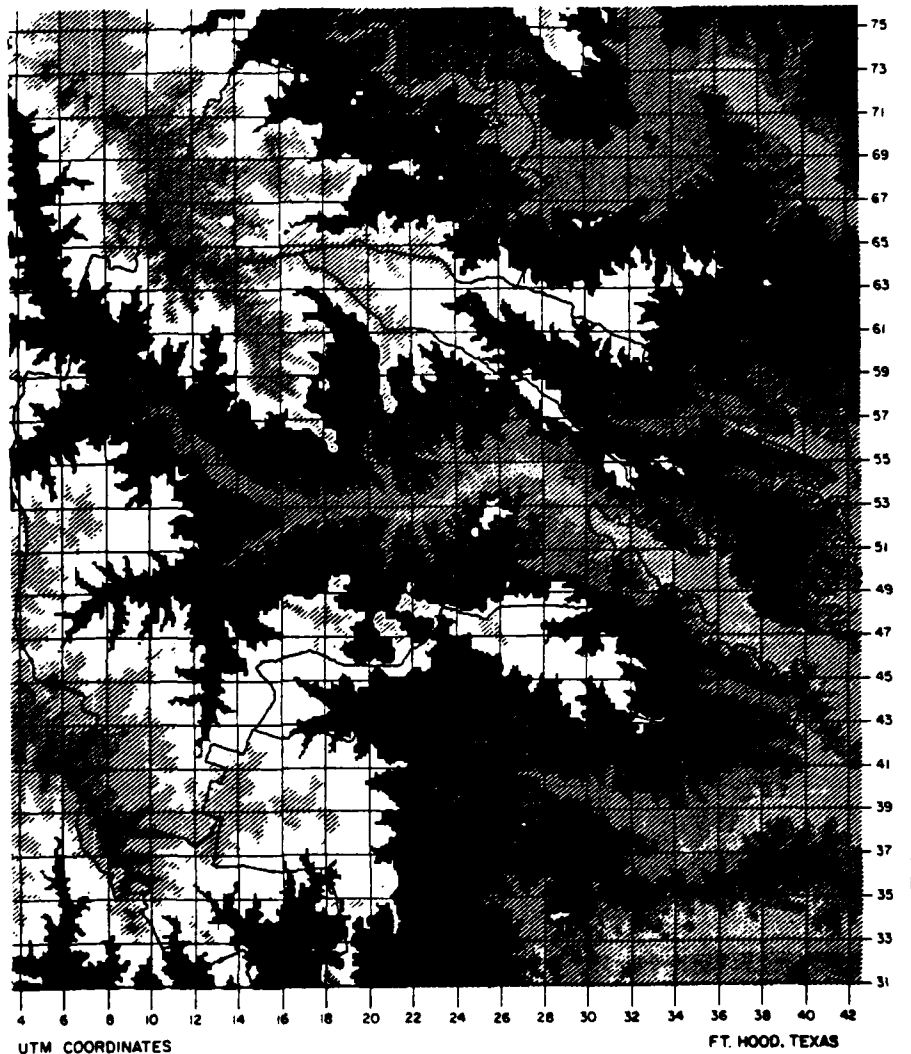
The user can orient the range in any compass direction, from 1 to 360 degrees. He can repeat this process as often as desired. However, in the ranges database, only one cell can be occupied by one range. Thus, overlaying one range across another will cut off the overlaid portion of the old range.

The user can erase this database at any time and can use the range.place program to restore ranges wherever desired to any position desired. *One problem to note, however, is that range placement does not affect the range data during the placement session -- only in subsequent sessions.*

ASIS. ASIS (Archaeological Sites Information System) is a subsystem developed to organize, manage, and manipulate tabular data on historic and prehistoric sites at Fort Hood. This system is described in Chapter 6. This choice allows the user to leave the geographic information system, run an ASIS session, then return to the GIS.

Soils. This option gives the user direct entry into the ETIS soils retrieval system (SIRS), but it also terminates the user session. When the user inputs a Fort Hood soil series name, the ETIS soils retrieval system lists all selected properties and use interpretations for that soil. The information in this system was obtained from the USDA Soil Conservation Service and is updated periodically. Two of the major categories in the Fort

ELEVATION ZONES (25 METER INTERVALS) AND MAJOR WATERSHED BOUNDARIES



This map illustrates the type of output provided by the dot matrix printer. In this map, zones of elevation are indicated by varying gray scales. Users can also select patterns to indicate area subcategories. While there are eight different 25-meter elevation zones in this map, only five different gray scale patterns were used. Thus, some of the repeating patterns represent different elevation zones. The major watershed boundaries have been enhanced for greater visibility.

Figure 8. Example of dot matrix display.

Hood database contain soils data, so this link to the SIRS ETIS system can provide the user with detailed information about Fort Hood soils.

5. *Exit*

The user can end a session by hitting a break or a rubout key, or through the exit option in the main option table. Sessions can be saved, however, only if the exit option is selected. A saved session is simply a file with all of the user input. This file can then be used for several purposes, such as: (1) picking up an analysis session at the same point where the user left off, (2) saving an analysis, in case the user wishes to repeat it to save time in the future, (3) providing a demonstration session to show other persons, (4) providing an editable file to run a particular session, with some changes, by editing the responses in the saved file, rather than entering the system again, and (5) making a saved file out of a session. Figure 9 provides an example of a saved file from a Fort Hood Information System (FHIS) session. Appendix C provides an example session.

```

n          (no noise protection)
n          (non-verbose mode)
n          (not on video terminal)
1          (area selection choice: UTM coordinates)
2804e0     (southwest corner coordinates)
432610     (northeast corner coordinates)
4 10 11 14 23 25 30 (major category choices)
4          (satisfied with major category choices)
1 4        (subchoices in major category 4: sites)
6          (subchoice in major category 10: bdry)
8          (subchoice in major category 11: mvmt)
4 5 6 7    (subchoices in major category 14: slpe)
1          (subchoice in major category 23: arpa)
1          (subchoice in major category 25: ends)
1 3 4      (subchoices in major category 30: sprb)
4          (satisfied with major category choices)

*****CREATES MAP LAYERS 1 THRU 13*****

1          (operators)
2          (the "or" operation)
5          (overlay A: item 5)
6          (overlay B: item 6)   CREATES MAP LAYER 14
1          (operators)
2          (the "or" operation)
7          (overlay A: item 7)
14         (overlay B: item 14)  CREATES MAP LAYER 15
1          (operators)
2          (the "or" operation)
8          (overlay A: item 8)
15         (overlay B: item 15)  CREATES MAP LAYER 16
1          (operators)
2          (the "or" operation)
17         (overlay A: item 17)
10         (overlay B: item 10)  CREATES MAP LAYER 18
1          (operators)
2          (the "or" operation)
16         (overlay A: item 16)
18         (overlay B: item 18)  CREATES MAP LAYER 19
1          (operators)
2          (the "or" operation)
1          (overlay A: item 1)
2          (overlay B: item 2)   CREATES MAP LAYER 20
1          (operators)
2          (the "or" operation)
19         (overlay A: item 19)
20         (overlay B: item 20)  CREATES MAP LAYER 21
1          (operators)
1          (the "and" operator)
11         (overlay A: item 11)
21         (overlay B: item 21)  CREATES MAP LAYER 22
1          (operators)
1          (the "and" operator)
12         (overlay A: item 12)
21         (overlay B: item 21)  CREATES MAP LAYER 23
1          (operators)
1          (the "and" operator)
21         (overlay A: item 21)
13         (overlay B: item 13)  CREATES MAP LAYER 24
2          (tables)
2          (statistics table)   CREATES STATISTIC TABLE FOR ALL ITEMS
1          (operator)
2          (the "or" operation)
3          (overlay A: item 3)

21         (overlay B: item 21)  CREATES MAP LAYER 25
3          (graphics)
3          (hardcopy display, non-device specific)
25         (data item to be displayed)
9          (scale factor, vertical)
4          (scale factor, horizontal)
1          (session can be picked up at this point, if user
C          enters "this < gorenconflicts" - which is the name
          of this save file)

```

Only the numbers and letters on the left hand column comprise the original save file. All other material is added to interpret this sequence of user responses.

Figure 9. Saved file.

4 SYSTEM DESIGN AND MAINTENANCE

ETIS Interface

Throughout the development of the Fort Hood/ETIS pilot system, attempts have been made to tie the database into existing ETIS programs. This integration is especially promising with the soils data, since any Fort Hood soils type (and a complete list of soils characteristics) can be found in the ETIS soils library. The ETIS air quality and soil erosion models should also provide useful links to the Fort Hood database.

ETIS operates on the interactive UNIX* operating system. UNIX provides many user-unique capabilities for data storage and manipulation. Fort Hood can keep copies of the Fort Hood/ETIS pilot system database files in separate UNIX files and use existing UNIX features to edit, move, copy, sort, or search those files. For example, data files for each of the training areas could be created, then searched by line number, keyword, or key phrase, and sorted or edited using one of the three UNIX editors. If desired, an updated or edited file could replace an out-of-date or unedited version in the Fort Hood/ETIS pilot system's database. The UNIX system can also provide statistical packages, a mail function, and other capabilities which will increase the flexibility and efficiency of the Fort Hood/ETIS pilot system.**

Data Storage

The data storage system used to accommodate the Fort Hood database represents more than 180,000 one-hundred-meter-square cells. Because each major category in the database occupies an entire array of cells, regardless of the amount of actual data in the array, this creates a phenomenal number of cells. To accommodate this large amount of data, a storage system was devised using a numerical category for each grid cell classification. This storage system requires only 31 bits per cell.

Data Manipulation

The data are manipulated using a modified binary algebra. Sets of matrices are used to represent the data, with each matrix representing a particular data category. Each element of the matrix stores the value 0 or 1,

* UNIX is a trademark of Bell Laboratories.

**References on the UNIX operating system include: (1) Rebecca Thomas and Jean Yates, A User Guide to the UNIX System (Osborne, McGraw-Hill, Berkeley, CA, 1982); (2) Bell Telephone Laboratories, Inc., UNIX Programmers Manual (Holt, Rinehart, and Winston, New York, 1983 and 1979).

depending on whether that variable exists in that particular area.* To overlay two variables, the values for corresponding cells are combined to determine the condition in the combined cell.

This binary system requires the data to be converted to binary format within the program by having the computer scan through the input array to find the desired values. If a value equals the value desired, it is replaced with a 1; if not, it is replaced by a 0. Although this intermediate step takes some time, the program still executes very quickly.

As noted in Chapter 3, five manipulation options let the user overlay variables: "AND", "OR", "NOT AND", "NOT", and "NOT OR" operations. These operations are shown in Figure 6. In these overlay operations, any item from the data table can be selected as Variable A or as Variable B. Each of the four operations involves making a mask. When this mask is complete, a new item is added to the data table. This new item can then be chosen as a variable in further overlay operations.

Option 1; the A "AND" B Operation

To find areas where two variables occur simultaneously, a set operation of intersection is preferred. Using the "AND" operation, a mask is created that represents all locations where both Variable A and Variable B occur. When the mask is completed, cells where both conditions exist (1 and 1) will have a final value of 1. Cells where neither condition exists (0 and 0), or where only one condition exists (1 and 0, or 0 and 1) will have a final value of 0.

Option 2; the A "OR" B Operation

To find areas where either Variable A, Variable B, or both variables occur, a set operation or union is performed. Using the "OR" operation, a mask is created that represents all locations where Variable A or Variable B occurs. In this mask, cells where either condition exists (1 and 0 or 0 and 1), or cells where both conditions exist (1 and 1), will have a final value of 1. Cells where neither condition exists (0 and 0) will have a final value of 0.

Option 3; the "NOT" Operation

This operation does not combine two variables. Rather, it reverses the value assigned to any chosen variable. Thus, where Variable A was 1, it becomes 0, and non-A areas that were 0 become 1. When this new "NOT A" variable is combined with another variable, it allows users to locate cells where B occurs, excluding areas where A also occurs.

* The "1" is actually a unique symbol character assigned sequentially to each variable in the data table. A new symbol is assigned for every mask created by overlay manipulations. In hardcopy display options, the appropriate symbol is then printed for each display character in the cell where it occurs.

Option 4; the A "NOT AND" B Operation

An exclusion operation is performed to find the area where the combination of two variables does not occur. In this operation, a mask is created using two buffers and the "NOT AND" operation. This mask represents all locations where the combination of Variables A and B does not occur. Thus, cells where either condition exists (1 and 0 or 0 and 1) will have a final value of 1. Cells where neither condition exists (0 and 0) will also have a final value of 1. Cells where both conditions exist (1 and 1) will have a final value of 0.

Option 5; the A "NOT OR" Operation

To exclude areas where either of two variables occurs, a "NOT OR" operation of exclusion is performed. First, two buffers are set up using the union operation. Then the buffers and the "NOT OR" operation are used to create a mask. In this mask, cells where neither condition exists (0 and 0) will have a final value of 1. Cells where either condition exists (1 and 0 or 0 and 1), or where both conditions exist (1 and 1), will have a value of 0.

Database Maintenance

The database for the Fort Hood/ETIS pilot system will have to be revised and updated periodically. Initially, CERL will do all the editing, updating, and restructuring. However, as Fort Hood users become more familiar with the system, installation personnel may do some updating and editing. Since Fort Hood has access to UNIX editing capabilities through the ETIS interface, files relating to specific management functions (e.g., grazing programs or game management activities or cedar clearing sites) can be created at Fort Hood and then entered into the database by CERL.

It may also be possible to program the data structure so that Fort Hood can enter new data directly. Point and line data are easily integrated into a database, since only a few cells are affected. And although area data are difficult and cumbersome to enter into a database without a digitizer, most area data are relatively static (e.g., soil type, watershed area, or geologic features) and should require only infrequent revision.

Hardware

The Fort Hood/ETIS pilot system has been developed on a DEC 11/780 VAX computer. The initial workstation will use a standard dot-matrix printer with appropriate acoustic coupling in coordination with a CRT graphics terminal (such as the DEC VT100 with Retrographics board). This workstation configuration costs less than \$20,000 and provides high-quality black and white visuals for both hardcopy printers and video screens. However, it requires long distance signal transmission over telephone lines.

In any form of graphic analysis, standard overprint technology is limited by the time required to access trouble-free communication lines. At Fort Hood, the efficiencies of graphics output are severely limited by broken transmission. One way to avoid this problem would be to house intelligent

terminals (microprocessors) at Fort Hood, and communicate with the central minicomputer only for occasional data. This allows usual ETIS efficiency in centralized update and maintenance and reduces the amount of data that must be transmitted over telephone lines. An onsite mini- or microcomputer at the Fort Hood Environmental Programs Office could also resolve the problems of high cost and restricted access that are inherent in telephone communication.

5 THE DATABASE

Grid Structure

The grid structure for the pilot system's database was created from Land Resources Satellite (LandSat) data. The LandSat data used for the Fort Hood database were collected on June 11, 1979, and obtained from the Earth Resources Observation Satellite (EROS) Data Center in Sioux Falls, SD. These data are recorded with electric scanners, then relayed to ground-based collection platforms. The ground area for the data image is a square skewed about 9 degrees from a north-south coordinate axis, and represents about 185 kilometers on a side. Only a little more than 5 percent of the total image area, or about 1814 kilometers square, was used for the Fort Hood database structure. This section measures about 40 kilometers east-west and about 45 kilometers north-south and corresponds to the rectangular area represented on the Defense Mapping Agency's Fort Hood Military Reservation Special Map. In the UTM coordinate system, the area selected for the data file from this LandSat image ranges from 3 430 000 to 3 476 250 meters north and from 603 500 to 543 250 meters east.

To create the grid network, the LandSat data file was oriented to be geometrically correct and referenced to the UTM system. Originally, the data file was organized into grids with cells representing 50 x 50 meters of land surface. However, to reduce the volume of data in the system and to coordinate the land cover with less detailed data, the cell size was increased to 100 x 100 meters, or 1 hectare per cell. Thus, the Fort Hood data grid has 181,429 cells, rather than 725,716 cells.

There are several advantages to this increased cell size. Because the computer requires only one-fourth as much time to search a data file and create a mask, sessions execute much more quickly. Also, only one-fourth as much computer memory is needed to store data, so the system is less expensive to maintain and operate. The major disadvantage of these larger cells is that their data are more generalized. However, data were not available for several of the major components of the Fort Hood database at the 50- x 50-meter cell size.*

All of the database's components were entered into this grid network of 100-meter-square cells. Each data category required a new file of 181,429 cells. Altogether, the database has 397 cells east-west (columns) and 457 cells north-south (rows) (see Figure 1). Not every data component has information for the entire grid. Because the installation's shape is irregular and this shape is contained entirely within a rectangular area, many of the grid cells occur outside Fort Hood's boundaries. However, of the system's current primary data categories, only landcover, elevation, slope, aspect, noise contours, streams, and boundaries contain information for off-installation areas.

* For example, nonurban cultural features were listed in the Fort Hood Terrain Analysis grid by six-digit UTM coordinates at the 100-meter level of detail. Unless an onsite determination was conducted for each item, those features could only have been arbitrarily assigned to one of four 50-meter cells.

Major Data Elements

Table 1 lists the ETIS/Fort Hood pilot system's current 30 primary data categories. The table lists, for each primary category, the type and source of data, the number of subcategories, the four-letter name of the system textfile, and the name of the backup helpfile (if one exists). The user does not have to know the names of textfiles and helpfiles; they are listed in Table 1 only for informational purposes. Appendix A lists the subcategories within the major categories, and Appendix B includes helpfiles (when available) for each data type.

Although many sources were consulted to obtain the pilot system data, one major source was Fort Hood, Texas, Terrain Analysis (July 1977), prepared by the 64th Engineer Detachment (Terrain) of Fort Hood under the direction of the Terrain Analysis Center, U.S. Army Engineer Topographic Laboratories, Fort Belvoir, VA. Information for Category 1 (engineering geology), Category 2 (lines of communication), Category 3 (nonurban cultural features), Category 9 (vegetation), Category 20 (engineering soils), and Category 21 (water resources) were all obtained from this document. No helpfiles were created for Categories 2 or 3; since these subcategory names are self-explanatory; however, detailed information about them, or about any of these other five major categories, can be obtained from this document.

Primary Category 1: Engineering Geology

The six subcategories of engineering geology information are based on the engineering characteristics related to the installation's lithography. These subcategories include four types of limestone, one type of shale, and one category of unconsolidated materials.

Primary Category 2: Lines of Communication

This category includes point, line, and area features. Line features include railroads, pipelines, and several subcategories of roads. Area features include airfields and airstrips, helicopter landing zones, and drop zones. Point features include pipeheads, pipeline tank crossings, and bridges.

Primary Category 3: Nonurban Cultural Features

The nonurban cultural features category lists 170 features under 23 subcategories such as "water-tower," "well," "campground," and "staging field." Each subcategory is in a separate file and can be searched separately during a session. All of the data in this category are point data.

Primary Category 4: Archaeological and Historic Sites

The list of archaeological and historic sites in the Fort Hood database was obtained from the Fort Hood archaeologist. These sites are in two subcategory files: prehistoric sites and historic sites. Each file already contains hundreds of sites and is updated frequently. The site data are identified with an eight-digit accuracy which, in the UTM coordinate system, defines a site within a 10-meter-square area. While the Fort Hood/ETIS pilot system cannot map sites at this accuracy, there are plans to modify the system so

Table 1
Data Categories

No.	Name	Textfile	Helpfile	No. of Subcategories	Information type	Source of Data
1	enrg-geology	geol	geolhelp	6	Engineering geology	Terrain Analysis
2	roads-airfields	line	none	17	Roads, airfields, pipelines	Terrain Analysis
3	cult.features	feat	none	23	Nonurban cultural features	Terrain Analysis
4	sites	site	none	2	Archaeological and historical sites	Fort Hood archaeologist
5	major basins	basl	baslhelp	6	Major watershed basins	Topographic map
6	landcover	lcov	lcovhelp	10	Landcover from LandSat	1979 LandSat data
7	soils	soil	soilhelp	64	Detailed soil map units	SCS Bell County Soil Survey Survey preliminary maps -- Coryell Co.
8	minor basins	basl	baslhelp	61	Minor watershed basins	Topographic map
9	vegetation	vegt	vegt help	15	Vegetation	Terrain Analysis
10	boundary	bdry	none	10 (5)*	Various types of boundaries	Topographic map
11	c-c movement	mvmt	mvmt help	8	Classification of areas for movement	Topographic map
12	ranges	rngs	none	20 (3)*	Placement of ranges	Various
13	elevation (25 meters)	elev	elev help	10 (8)*	Zones of elevation	DMA tapes
14	slope	slpe	none	7	Degree of slope	DMA tapes
15	aspect	aspc	aspc help	8	Direction of slope	DMA tapes
16	training areas	tran	tran help	95 (65)*	Areas for training use	Training area map
17	training frequencies	trfg	trfg help	5	Frequency of usage -- training areas	1980 G-3 operations data
18	training intensities	trin	trin help	4	Intensity of usage -- training areas	1980 G-3 operations data
19	training outlines	trot	none	1	Outlines of training areas	Training area map

Table 1 (Cont'd)

No.	Name	Textfile	Helpfile	No. of Subcategories	Information Type	Source of Data
20	engineering soils	enso	ensohelp	6	Soil classes by engineering properties	Terrain Analysis
21	water resources	wtrs	wtrshelp	10	Ground and surface water availability	Terrain Analysis
22	archaeological surveys	arav	none	5	Areas surveyed for archaeological sites	Fort Hood Archaeologist
23	protected archaeological areas	arps	none	2	Areas protected because of archaeological sites	Fort Hood Archaeologist
24	ecological survey sites	ecss	none	5	Sites where ecological surveys were conducted	Ecological Baseline Report
25	endangered species	ends	none	3	Identified ranges of endangered species	Ecological Baseline Report
26	noise contours	nact	noishelp	4	Noise level zones	CERL-EN Acoustics Team
27	streams	stms	none	1	Streams	Topographic Map
28	elevation (5 meters)	elfe	none	50	Elevation at 5 meter intervals	DMA tapes
29	experimental a	xpra	none	10	Experimental	
30	experimental b	xprb	none	10	Experimental	

*Actual number of categories containing data.

that users can ask for coordinate lists for point data. These lists then could be used to separately identify multiple sites occurring within a single data cell. No helpfile exists for this category, but extensive files were organized to prepare these data for entry into the system. These files were used as the database for the Archaeological Sites Information System, as described in Chapter 6.

Primary Categories 5 and 8: Major Basins and Minor Basins

Major and minor watershed boundaries were determined from elevation contour lines on the Fort Hood Military Reservation Special Map. Six major basins were defined: Leon River, Owl Creek, Cowhouse Creek, Belton Reservoir, Nolan Creek, and Lampasas River.

These six basins are subdivided into the 61 sub-basins that comprise Primary Category 8, "minor basin." (Major basins and sub-basins are shown in Figure 10; each of the six major basins is assigned a letter A through F). The 61 sub-basins are numbered sequentially, according to the major basin in which each occurs. Each sub-basin is identified by a name. Appendix B gives the helpfile listing these names.

Primary Category 6: Land Cover

The information in the land cover category is based on Landsat imagery. The Landsat satellite records the spectral response of the land surface in four electromagnetic bands: Band 4 (green); Band 5 (red); Band 6 (first infrared); and Band 7 (second infrared).

In the method used to determine land cover categories for the Fort Hood/ETIS pilot system, data from all four spectral bands were sampled by computer. These samples were grouped using a clustering analysis. The entire data set then was classified by a maximum-likelihood classifier, using the statistics generated for each class. The spatial patterns generated by this technique were compared with several other sources of information, including high-altitude color infrared aerial photographs; large-scale black-and-white aerial photographs; topographic maps; and detailed soil surveys.

None of the land cover classes defined and generated for the Fort Hood database had to be changed when verified against other sources. However, the spectral responses from urban areas created a spotty and confusing classification pattern, so limited areas near Killeen and Copperas Cove were reclassified as urban. The 10 Fort Hood land cover classes are listed in Table 2.

The Fort Hood land cover classification scheme is based on land cover, not land use. But because certain types of land cover are associated with specific land uses, inferences can be made about land use from the spectral data. For example, the classifications "bare area" and "disturbed area" can be differentiated by surface response. The bare area classification means there is some vegetation component or that the area has darker organic soils. The disturbed area classification includes extremely bright spectral response areas, signifying the presence of a hard surface such as concrete or gravel or seriously denuded soil. Areas on the western edge of the installation have been exposed to intensive heavy armored vehicle training and heavy grazing, which accounts for the abundance of disturbed land in this area. On the

FORT HOOD MILITARY RESERVATION
WATERSHEDS

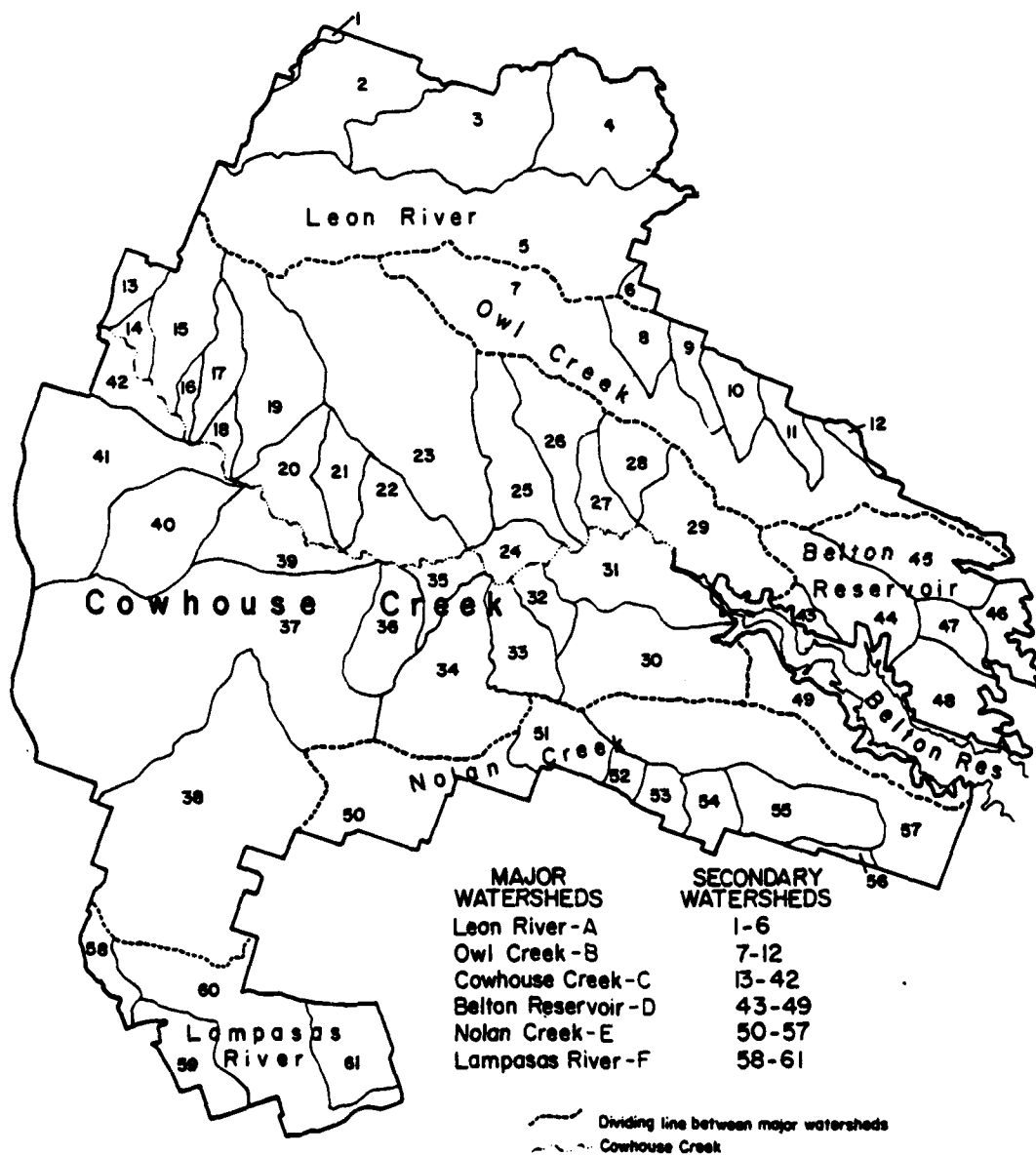


Figure 10. Major basins (primary category 5) and minor basins (primary category 8).

Table 2

Land Cover Classes

Item	Net Area				Percent Total Area
	km ²	hectares	sq mi	acres	
1. lcov: other	34.83	3483.0	13.43	8610	1.9
2. lcov: water	59.04	5904.0	22.77	14595	3.3
3. lcov: forest	218.03	21803.0	84.08	53897	12.0
4. lcov: shrub	386.32	38632.0	148.98	95498	21.3
5. lcov: shrub & grass	237.37	23737.0	91.54	58678	13.1
6. lcov: grass	200.52	20052.0	77.33	49569	11.1
7. lcov: bare	289.69	28969.0	111.72	71611	16.0
8. lcov: agriculture	78.24	7824.0	30.17	19341	4.3
9. lcov: disturbed	242.63	24263.0	93.57	59978	13.4
10. lcov: urban	67.62	6762.0	26.08	16716	3.7

eastern side of the installation, the land cover is typified by extensive forests, healthy shrub and grassland, and large reservoirs. The southern section is heavily urbanized and transversed by a major highway. The northern section changes from range land (in the west) to training areas and forest (in the central section) to agricultural and grazing areas (in the east).

The land cover classification must be considered in relation to factors that may change conditions in the area. For example, seasonal variation in life cycles affects vegetative cover (especially in grassland and shrub areas), yearly fluctuations in precipitation cause changes in the health and density of vegetation, and drawdown experienced by reservoirs may also cause changes.

Primary Category 7: Soil Type

Soils information for the Fort Hood database came from two sources. The source for Bell County was Soil Survey of Bell County, Texas (U.S. Department of Agriculture, Soil Conservation Service [SCS], March 1977). For Coryell County, preliminary soil survey maps were obtained from the SCS State Office in Temple, TX. The soils information in the Fort Hood database includes only areas within the installation's boundaries. However, information was obtained for all areas within these boundaries.

Each of the more than 60 soil mapping units on the installation was assigned a subcategory file. Generally, each mapping unit represents a single soil series. However, a mapping unit may be only one type of a particular series. For example, houston black clay on a 0 to 1 percent slope is named HoA and houston black clay on a 1 to 3 percent slope is named HoB. In some cases, two separate series occurring in a landscape pattern were grouped and identified as a complex, such as the Doss-Real complex. Large areas of both

Coryell and Bell County are identified as mapping unit complexes, which makes it more difficult to determine what series occurs at any one location within that complex unit.

The SCS soil data in the existing ETIS database provides a tremendous information supplement to the Fort Hood database. As noted in Chapter 3, users can access this information directly from the Fort Hood database, but cannot return directly to the pilot information system. As input, the ETIS soils program required only a series name. Information options within the ETIS program include soil description, tables of properties, use interpretations, yield capability, and potential native plants. The ETIS program has information on all identified and described soil series in the United States. However, there are some proposed new series in Coryell County. In cases where these new soils are not included in the ETIS soils database, similar soils that can be used as substitutes have been identified in the Fort Hood soil subcategory lists.

Primary Category 8:

See Primary Category 5, page 35.

Primary Category 9: Vegetation

The vegetation category has 15 subcategories based on vegetative type (forest, scrub, or grass), species (coniferous, mixed, and deciduous), and degree of canopy closure. The vegetation data are similar to land cover data, but are based more on detailed vegetative characteristics rather than on characteristics relating to land use.

Primary Category 10: Boundaries

Within this major category are subcategory choices such as installation boundary, impact area boundary, county line boundaries, major roads, railroads, and major UTM grid reference line. One of the main purposes of these data are to provide recognizable linear features to help orient point and area features on display maps. All of the boundary data were obtained from the Fort Hood Military Reservation Special Map. Both on- and off-installation areas were included. While there are 10 subcategory choices in this primary category, not all choices presently have data.

The boundaries data are all linear, yet each cell of data occupied by a particular boundary subcategory is a 100- x 100-meter area. Since this is much wider than the actual physical width of a road or the nonphysical width of a grid line, the area statistics for this and other linear data are exaggerated.

Primary Category 11: Cross-Country Movement

This database, taken from Fort Hood, Texas, Terrain Analysis, evaluates the installation's terrain for cross-country movement. Topography, soil properties, vegetation, and surface wetness were all considered in establishing its eight subcategories. Each subcategory is assigned a rating (good, fair, poor, not suited) for various types of cross-country vehicle and troop movement during both wet and dry periods. A table listing these ratings is in the

helpfile. In a sense, this category is an "overlay" of several databases for a specific type of analysis.

Primary Category 12: Ranges

The range data that are manipulated in range.place (one of the options in externals) are contained in this primary data category. Only three types of ranges are available: (1) XM-1 tank range, (2) Dragon missile range, and (3) TOW missile range. For each of these three ranges, the total range and firing fan have been entered as one category. However, unlike other data, it has not been located in a fixed coordinate position. Rather, the dimensions of these ranges have been digitized and can be placed anywhere within the boundaries of the database through the range.place capability. The only limitation to this capacity is that two ranges cannot be assigned to the same cell; in such cases, the most recent placement of a range will replace previous placements.

Primary Categories 13, 14, and 15: Elevation, Slope, and Aspect

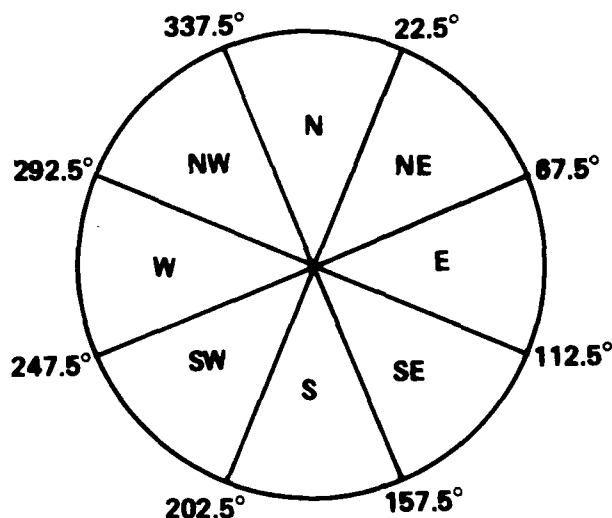
Elevation data have been obtained from the Defense Mapping Agency. These data, stored on computer tape, are elevation readings for the entire installation at 12.5-meter intervals. From these data, each of these three primary categories -- zones of elevation (Category 13), degree of slope (Category 14), and direction of slope (Category 15) -- have been calculated. While the original data are in the form of point readings at 12.5-meter intervals across the entire topographic surface, these data have been converted into area data, with each 1-hectare cell assigned to a specific zone of elevation (e.g., 250 to 300 meters), a percent range of slope (e.g., 5 to 10 percent), and a compass-oriented direction of slope (e.g., facing northeast).

These are eight zones of elevation, divided at 25-meter intervals, starting with 200 meters. The seven slope categories are 0 to 2 percent, 2 to 5 percent, 5 to 10 percent, 10 to 15 percent, 15 to 20 percent, 20 to 25 percent, and > 25 percent. There are eight aspect directions, N, NE, E, SE, S, SW, W and NW. Each category is 45 degrees. Figure 11 indicates the beginning and ending of each of these zones.

The area for which these data are available is slightly different from the area of the database. Small parts of the southern and the eastern extremes of the database are not available. (The data extend beyond the west and north borders of the database, and data are continuous for on- and off-post installation areas.)

Primary Categories 16 through 19: Training Areas, Frequencies, Intensities, and Outlines

Four separate main categories relate to training areas. Primary Category 16 has area data for each of Fort Hood's numbered training areas. The subcategories are numbered 1 through 95. Subcategory 94 is the permanently duded area within the impact area, and Subcategory 95 is cantonments and airfields. Because these training areas are not numbered sequentially, there are fewer than 95 actual training areas. Thus, many subcategory slots are empty. Figure 12 shows the location and number of each training area in the Fort Hood base.



1. N	337.5° - 22.5°	5. S	157.5° - 202.5°
2. NE	22.5° - 67.5°	6. SW	202.5° - 247.5°
3. E	67.5° - 112.5°	7. W	247.5° - 292.5°
4. SE	112.5° - 157.5°	8. NW	292.5° - 337.5°

Figure 11. Aspect diagram -- direction of slope.

The data for training frequency (Primary Category 17) and training intensity (Primary Category 18) were obtained from 1980 schedules for maneuver area use. Primary Category 17 is simply a count of maneuver events per year per acre. It has five subcategories. Data for Primary Category 18 (intensity) was more difficult to obtain. To find the intensity of use of each area, three elements were considered:

1. The type of maneuver activity, e.g., bivouac, escape and evasion, land navigation.
2. The type of unit involved in the exercise, e.g., armored division, signal brigade.
3. The size of the unit, e.g., squad, company, brigade.

After these factors were considered, each area was assigned to one of four intensity subcategories.

Primary Category 19 was created to store the outlines of each of these training areas. Because there is only one subcategory choice for Primary Category 19, a user who chooses this subcategory will be given training area outlines for his entire on-post working area.

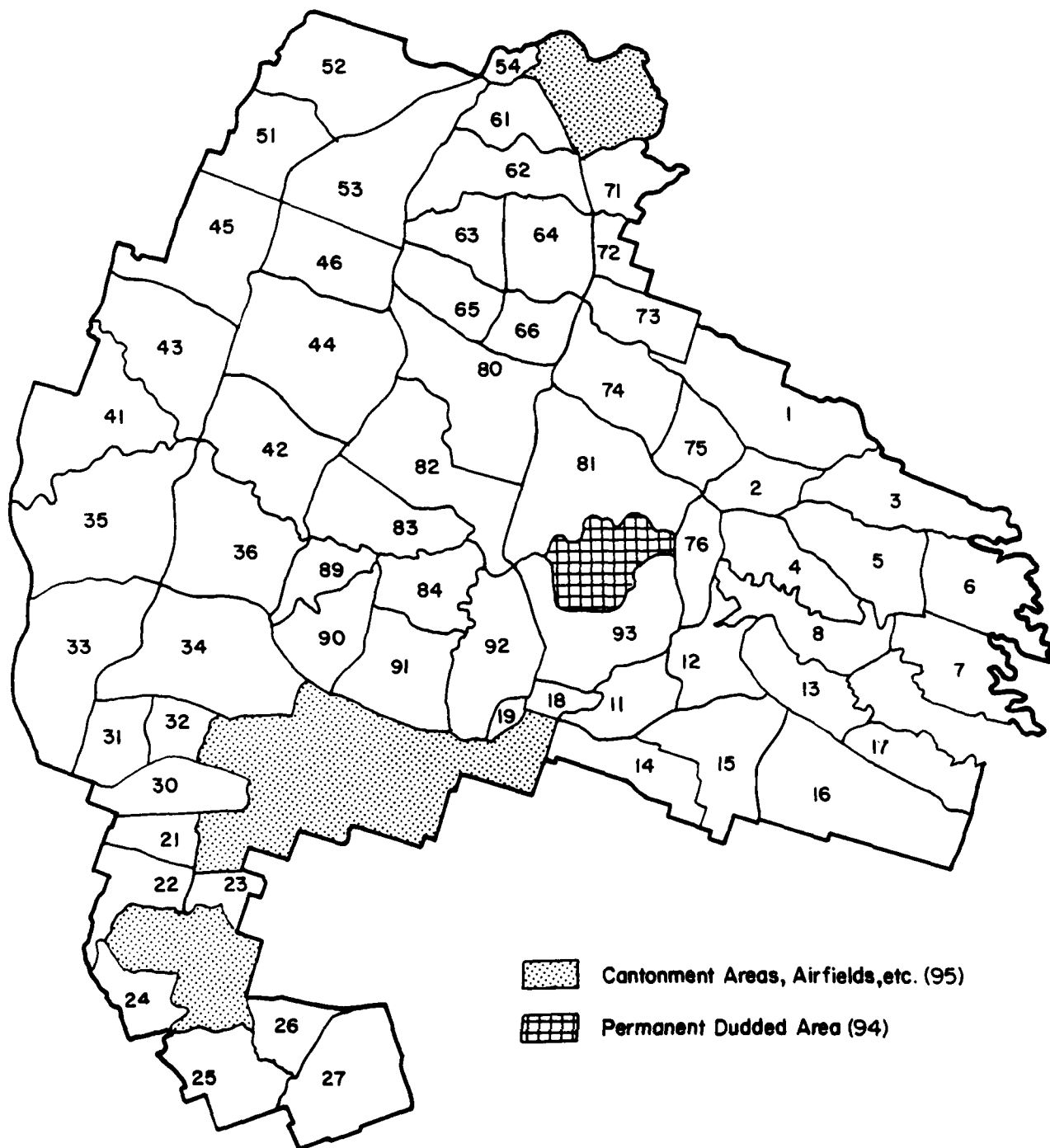


Figure 12. Fort Hood military reservation training areas.

Primary Category 20: Engineering Soils

Six subcategories of engineering soils are used in the pilot system. Each is based on soils engineering characteristics like texture, plasticity, and depth found in Fort Hood, Texas, Terrain Analysis. Each subcategory is very broad, similar to the subcategories in Primary Category 1 (engineering geology). Soils data are available at a much more detailed level in Primary Category 7 (soils), in which the subcategories relate to series and complexes of series. However, the data in the six subcategories of Primary Category 20 are interpretive; that is, each subcategory is analyzed for particular engineering uses. Detailed information on these analyses are available in the engineering soils helpfile (ensohelp).

Primary Category 21: Water Resources

Primary Category 21 has 10 subcategories. Two subcategories have area data which relate to groundwater resources. The other eight subcategories use line data to rate the major on-installation streams according to their surface water resources. Four of these subcategories are of perennial streams, and four are of seasonal streams. (Not all on-post streams are included in one of these eight subcategories.) Data for Primary Category 21 were obtained from Fort Hood, Texas, Terrain Analysis. A table from that document is in the helpfile (wrtshelp). This table lists quantities of flow for surface streams.

Primary Category 22: Archaeological Surveys

These data identified all areas at Fort Hood that have been surveyed for historic and prehistoric sites. Subcategory designations have been assigned by the Fort Hood archaeologist, based on the fiscal year in which these surveys were conducted. Generally, these surveys involved blocks of one-square-kilometer areas, but in some cases, surveys were conducted along linear strips. There are a total of 15 data slots available in this category, but at present, data have been entered only in slots 1 through 5, starting with fiscal year '78 surveys in slot 1. As more surveys are conducted in future fiscal years, new data can easily be added.

Primary Category 23: Protected Areas

There are only two subcategories within this category: (1) limited-use areas and (2) off-limits areas. At present, there are only two limited-use sites. Only one site is entirely off limits for training use; it is a Boy Scout camp in the southeastern corner of the post.

Primary Category 24: Ecological Survey

Baseline ecological surveys were conducted at Fort Hood in the autumn of 1977 and in the spring of 1978. The locations of these sites are indicated in this data category. There are five subcategories, each representing a different type of study site: (1) aquatic sampling stations, (2) vegetation sampling stations, (3) animal sampling stations, (4) tracked vehicle study sites, and (5) road cruise bird census. Sites in categories 1, 2, and 3 are very small and thus provide essentially point data. The two sites in Category 4 are somewhat larger. The road cruise census sites are linear. The source of the information in this category and the source for further information on

these sites is CERL Technical Report N-95/ADA088271, Ecological Baseline Study -- Fort Hood, Texas.

Primary Category 25: Endangered Species

No species on the Federal list of endangered species have been identified at Fort Hood, but some rare species, which appear on state lists, do occur on the post. The habitats of some of these species have been identified, and the areas of these habitats have been entered in this data category. While 25 species are listed as subcategories, on-post ranges have been described only for the golden-cheeked warbler (number 1) and the big tooth maple (number 17). No data now exist in the other subcategory slots.

Primary Category 26: Noise Contours

Four zones of "acceptability for noise-sensitive land use" have been identified through on-post studies by CERL acoustics researchers. A map resulting from these studies and indicating the location of each of these zones was digitized to create this data file, with Zones 1 through 4 as subcategories.

Primary Category 27: Streams

All the major streams that occur within the boundaries of the Fort Hood database were entered, as line data, into one data category.

Primary Category 28: Elevation (5-Meter Intervals)

This category is generated from the same data as Category 13. The only difference is that Category 13 is subdivided into eight zones with 25-meter intervals between zones, and Category 28 is subdivided into 50 zones, with 5-meter intervals between zones.

Primary Categories 29 and 30: Experimental A and B

These data categories are open for various projects of a temporary or experimental nature. At present, Category 29 is being used for some data relating to an on-going impact assessment. Category 30 is open, but it may also be used for this assessment. More open files can easily be added if future needs require more data.

6 THE ARCHAEOLOGICAL SITES INFORMATION SYSTEM (ASIS)

System Concept

Besides the archaeological and historic data within the geographic information system, a separate subsystem has been developed using site data provided by the Fort Hood archaeologist. This subsystem, called the Fort Hood Archaeological Sites Information System (ASIS) allows the user to search this site data by either geographic location or by user-specified categories.

ASIS was developed for two basic reasons. The first reason was to provide an organizational format in which site data could be efficiently stored, accessed, altered, searched, and duplicated and to which new sites could easily be added. Also, it was intended that this format be compatible with the larger geographic information system. The second reason was to provide a format which permits a variety of analysis of the site data. Not only can users conduct multivariant searches using system commands, but the organizational format of the site data also enhances a number of statistical analysis procedures. In the future, some of these statistical analysis capabilities may be incorporated into ASIS and be developed as general tools within the geographic information system.

At present, there are five data categories for each site: state number, field number, type, easting and northing, project, and sample unit. There are plans for these data categories to be expanded to include a long list of chronological, environmental, and functional categories. A preliminary list of these categories, which eventually may include more than 50 items per site, is provided in Table 3.

Of these five current data categories, the first -- *state* -- refers to the official seven-digit state number assigned by the State of Texas. *Field* refers to the three-digit number assigned by field teams to some sites during field surveys. Some sites now have field numbers, some have state numbers, and some have both. Eventually the Fort Hood archaeologist plans to obtain state numbers for all sites, and then use this numbering system exclusively. The category *type* simply refers to whether a site is considered historic (h) or prehistoric (p). The *east* and *north* entries are referenced to the UTM grid system, with each site given a four-digit easting and a four-digit northing. Sites are thus located to within a 10-square-meter area. *Project* refers to the survey or survey period in which the site was first identified, with "fhas" referring to the "Fort Hood Archaeological Society," "ih" to "in house," "fy 78" to "fiscal year 1978," etc. *Sample unit* refers to a catalogue number assigned to any materials obtained from or relating to that particular site.

System Operation

ASIS can either be entered as one of the external options in the geographic information system or it can be entered as a separate system from the

Table 3

Categories of Data for the Archaeological Sites Information System

Chronological Classification

I. Prehistoric Sites

- A. Historic Aborigine
- B. Late Prehistoric
 - 1. Austin
 - 2. Toyah
- C. Late Archaic
- D. Middle Archaic
- E. Early Archaic
- F. Paleo Indian
- G. Combination of above
- H. Unknown

II. Historic Sites

- A. Late Railroad (1910 - 1940+)
- B. Early Railroad (1881 - 1910)
- C. Prerailroad (to 1881)
- D. Combinations
- E. Unknown

Environmental Classification

I. Drainage - 2 River System

- A. Leon
 - 1. Cowhouse
 - 2. Henson
 - 3. Open
- B. Lampasas
 - 1. Clear Creek
 - 2. Gann Branch
 - 3. Reese Creek
 - 4. N. Reese Creek

II. Drainage - FHIS System

- A. Lean River
- B. Owl Creek
- C. Cowhouse Creed
- D. Bettar Reservoir
- E. Nolan Creek
- F. Lampasas River

III. Environmental Zone

- A. Upland
- B. Intermediate Upland
- C. Lowland

IV. Creek/Crest Classification

- A. Near Creek
- B. Near Crest

Table 3 (Cont'd)

V. Landform

- A. Outlier
- B. Butte
- C. Ridge/Plateau
- D. Bench
- E. Spur
- F. Draw
- G. Terrace
 - 1. Primary
 - 2. Secondary
 - 3. Tertiary
 - 4. Rudimentary
- H. Escarpment edge
 - 1. Open
 - 2. Open
- I. Hillock
- J. Knoll
- K. Open

VI. Position With Respect to Landform

- A. Top
- B. Slope
- C. Base
- D. Other
- E. Not Applicable
- F. Open

Functional Classification

I. Objective Types

- A. Cave
- B. Rock Shelter
- C. Midden
- D. Burned Rock Shelter
- E. Petroglyph
- F. Pictograph
- G. Burned Rock Mound
 - 1. Single
 - 2. Multiple
- H. Litter Scatter
 - 1. Light
 - 2. Moderate
 - 3. Heavy
- I. Combination
- J. Open

II. Functional Types

- A. Type A
- B. Type B
- C. Unknown
- D. Other

Table 3 (Cont'd)

Condition Classification

I. Qualitative

- A. Excellent
- B. Good
- C. Fair
- D. Poor
- E. Unknown

II. Quantitative

- A. Excellent
- B. Good
- C. Fair
- D. Poor
- E. Unknown

Special Considerations

I. Protectability

- A. Excellent
- B. Good
- C. Fair
- D. Poor
- E. Unknown

II. Overall Aesthetics

- A. Open
- B. Open
- C. Open
- D. Open
- E. Open

III. Scientific Value

- A. Open
- B. Open
- C. Open
- D. Open
- E. Open

IV. Open

- A. Open
- B. Open
- C. Open
- D. Open
- E. Open

Fort Hood home directory.* Once a user has entered ASIS, there is a slight delay (about 5 seconds) during which the program counts the total number of sites. All subsequent system responses occur without delay. Once the count is completed, the user is prompted to respond:

Welcome to the Fort Hood Archaeological Site Information System.
There are presently 638 sites on record.

What next? (Type '?' for help.):

At this level in the subsystem, there are five possible commands: geo, brac, cat, show, and quit. A user can also request help or specify help for a particular command, such as "help cat." If, after the initial prompt, the user responds with "?" or "help," the system will provide the following command summary:

Here is a list of commands available on ASIS:

'geo' selects a geographical area one kilometer square by easting and northing or the word 'all' may be used to select the entire Fort Hood area.

'brac' does bracket searches.

'cat' does categorical searches on the geographical area selected.

'show' displays the list of sites selected thus far.

'quit' exits ASIS.

To use any of the above commands, simply type the command name. You will be prompted for additional information if needed.

To obtain more information about any of the above commands, type 'help <command>', (i.e., 'help geo').

What next? (Type '?' for help.) :

The Geo Command

The geographic search can be used alone or in conjunction with the category search. Its use is explained in the following "help geo" file:

What next? (Type '?' for help.) : help geo

geo -Geographic search.

Geo selects geographic areas by entering four-digit easting and northing coordinates. Each set of coordinates

* Home directory refers to the directory of files and programs that reside at the location or address from which a specific user logs into the computer.

selects an area one kilometer square. The area specified by geo is the area which is used by the cat (Categorical Search) command; subsequent calls to cat will use the same area until a new one is specified by another call to geo.

If cat is invoked without calling geo and specifying an area for cat, cat will use the entire Fort Hood area by default. To set the area for cat to the entire Fort Hood area after a smaller area has been used, 'all' may be entered into geo instead of an Easting coordinate.

Once the geo command is initiated, the user can select one or several square-kilometer areas. Each UTM entry must be four digits -- four for both easting and northing. Thus, if a UTM easting is 950, it should be entered as 0950. Following is an example search using two different 1-square-kilometer areas for search entry.

What next? (Type '?' for help.) : geo

Select an area.

Enter Easting (or 'cr' if done.): 3400
Enter Northing : 4500
Enter Easting (or 'cr' if done.): 1850
Enter Northing : 5200
Enter Easting (or 'cr' if done.):

You have selected:

1. Easting: 3400 Northing: 4500
2. Easting: 1850 Northing: 5200

This area contains 7 sites.

In this search, seven sites were identified as occurring in one or the other of these square kilometer areas.

The Show Command

To obtain a listing of these seven sites, the "show" command is used. Instructions for using the show command are available by typing "help show" as follows:

What next? (Type '?' for help.): help show

Show displays the latest list of sites selected.

If show is called immediately on entering ASIS, the entire list of sites in the Fort Hood area will be displayed.

If show is called after an area is selected by the geo command, all the sites in that area will be displayed.

If show is called after a cat command, the sites selected by cat will be displayed.

When the show command is invoked, at the beginning of the program or after a geo or cat search, it provides four different saving options: state number, field number, easting, and northing. Each of these options sorts from lowest to highest. In the following example, show is invoked after the above geo search and the seven sites are sorted, first by easting and then by state number:

What next? (Type '?' for help.) : show
Would you like data sorted by:

1. State
2. Field
3. Easting
4. Northing

Type number for response.

3

	State	Field	Type	East	North	Project	Sample Unit
1.	41cv213	232	h	1836	5253	fy78	18-52
2.	41cv209	228	p	1836	5253	fy78	18-52
3.	41cv197	211	h	1860	5274	fy78	18-52
4.	41cv196	210	h	1875	5270	fy78	18-52
5.	41cv212	231	p	1890	5238	fy78	18-52
6.	41cv159	-1	p	3427	4597	fhas	n/a
7.	41cv162	-1	p	3430	4580	fhas	n/a

What next? (Type '?' for help.) : show
Would you like data sorted by;

1. State
2. Field
3. Easting
4. Northing

Type number for response.

1

	State	Field	Type	East	North	Project	Sample Unit
1.	41b1159	-1	p	3427	4597	fhas	n/a
2.	41b1162	-1	p	3430	4580	fhas	n/a
3.	41cv196	210	h	1875	5270	fy78	18-52
4.	41cv197	211	h	1860	5274	fy78	18-52
5.	41cv209	228	p	1836	5253	fy78	18-52
6.	41cv212	231	p	1890	5238	fy78	18-52
7.	41cv213	232	h	1836	5253	fy78	18-52

From these lists, it is clear that sites 1 and 2 occur in the 3400/4500 area, and the other five sites occur in the 1850/5200 area.

The Cat Command

If used subsequent to a geo command, the cat command will search only the list identified in the previous geo command. In this case, since there are only seven sites, such a search would be of little value. If a user wants to search the entire database with the cat capabilities, he can either begin a session in cat, or he can re-enter geo command and respond "all" to the first request to enter easting. In this example, since the user has completed his geo search, he re-enters geo as follows:

```
What next? (type '?' for help.) : geo
Select an area.
Enter Easting (or 'cr' if done.): all
```

You have selected the entire Fort Hood area, which contains 638 sites.

Within the cat command, there are "and," "or," and "except" search commands. These search capabilities, which resemble in concept the overlay capabilities of the geographic information system, are explained in detail in the help cat file, as follows:

```
What next? (Type '?' for help.) : help cat
```

cat - Categorical Search.

Cat searches an area specified by geo; if an area is not specified by geo, the entire Fort Hood area is used. From 1 to 10 terms may be entered; each term must be identified as belonging to a category, and each category is designated a number for this purpose. Relationships between terms are specified by using the operators 'and,' 'or,' or 'except.' The operator 'and' designates an intersection, 'or' a union, and 'except' an unwanted term. Parentheses may be used to group terms, but may not be nested.

example:

```
1. state 2. field 3. type 4. project 5. sample unit <---This line shows
                                                    designated
                                                    numbers for
                                                    categories and
                                                    is displayed
                                                    for the user
```

```
: 3. h and 4. fhas
```

The above line will cause cat to select each site that has 'h' in the 2. category (type) and has 'fhas' in category 4 (project). Both conditions must be satisfied.

```
<-- cr
```

with the 'and' operator for selection. Note that a '.' must follow the number which identifies the category and each

element of the line must be separated by a space;
this includes parentheses if they are used.

: 2. h or 3. fhas

This will select each site with 'h' for type and 'fhas' for project. Only one condition need be satisfied with the 'or' operator.

: (2. h & 3. fhas) : (2. p & 3. ih) - 1. 41cv45

Here parentheses are used to group terms together, and single-digit symbols '&', ':', and '-' are used for the 'and,' 'or,' and 'except' operators, respectively. The '-' symbol for the 'except' operator will cause a site not to be selected if it has '41cv45' for State even if any or all other conditions are satisfied.

At present, with only five categories of data per site, the search capabilities in cat are under-used. As more of the environmental, functional, and chronological site data are entered into the system, these search capabilities will prove more useful. Following is an example search, using the cat commands:

What next? (Type '?' for help.) : cat

1. state 2. field 3. type 4. project 5. sample unit

: 3. p and 4. fy79

You have selected 17 sites so far.

To obtain a list of these 17 sites, the show command is called again. In the following example, a sort was requested by field number (2):

What next? (Type '?' for help.) : show

Would you like data sorted by:

1. State
2. Field
3. Easting
4. Northing

Type number for response.

2

	State	Field	Type	East	North	Project	Sample Unit
1.	41cv216	235	p	1897	4986	fy79	18-49
2.	41cv217	236	p	1835	4940	fy79	18-49
3.	41cv218	237	p	1618	4860	fy79	16-48
4.	41b1217	239	p	2780	5050	fy79	27-50
5.	41b1218	240	p	2781	5012	fy79	27-50
6.	41cv219	241	p	1730	4811	fy79	17-48
7.	41cv220	242	p	1752	4809	fy79	17-48

8.	41cv221	243	p	1781	4836	fy79	17-48
9.	41cv223	245	p	1811	4848	fy79	18-48
10.	41cv227	249	p	807	4005	fy79	08-40
11.	41cv230	259	p	2312	5032	fy79	23-50
12.	41cv243	273	p	1981	4823	fy79	19-48
13.	41b1228	281	p	2588	5050	fy79	25-50
14.	41cv250	283	p	2073	5017	fy79	20-50
15.	41cv251	284	p	2084	5082	fy79	20-50
16.	41cv253	286	p	2104	5056	fy79	21-50
17.	41cv267	300	p	2056	5158	fy79	20-51

Note that the show command lists the qualifying sites from the most recent site search. When a new search is initiated, during a single user session, the old list of sites from the previous session is replaced. A subsequent cat command, unless following a geo command (other than 'all') will begin a new search of the entire data file.

The Brac Command

This command allows the user to define a field of interest by state or field number. It is explained in help brac as follows:

What next? (Type '?' for help.) : help brac

Brac executes bracket searches by state or field code.
Upper and lower bounds are entered; all sites which
fall within these bounds are selected.

When the command is called, the user is given these two options, and then asked to define lower and upper bounds of the list, as follows:

What next? (Type '?' for help.) : brac
Would you like to do a Bracket Search by:
1. State
2. Field
Type 1 or 2 2
Enter, inclusively:
Lower bound: 380
Upper bound: 420

You have selected 41 sites so far.

This list could then be searched with cat commands, or listed with the show command. In the following example, the "sort" and these 41 sites is by easting:

What next? (Type '?' for help.) : show
Would you like data sorted by:
1. State
2. Field
3. Easting
4. Northing
Type number for response
3

	State	Field	Type	East	North	Project	Sample Unit
1.	-1	396	h	1610	5230	fy80(s)	16-52
2.	-1	400	h	1615	5550	fy80(s)	16-55
3.	-1	397	p	1650	5275	fy80(s)	16-52
4.	-1	395	p	1675	5265	fy80(s)	16-52
5.	-1	394	h	1680	5270	fy80(s)	16-52
6.	-1	403	h	1800	5808	fy80(s)	18-58
7.	-1	401	h	1826	5726	fy80(s)	18-57
8.	-1	402	h	1864	5722	fy80(s)	18-57
9.	-1	386	p	1950	6190	fy80(s)	19-61
10.	-1	407	p	2004	5556	fy80(s)	20-55
11.	-1	404	h	2022	5823	fy80(s)	20-58
12.	-1	408	h	2058	5612	fy80(s)	20-56
13.	-1	387	h	2100	5228	fy80(s)	21-52
14.	-1	406	h	2108	5732	fy80(s)	21-57
15.	-1	388	p	2125	5235	fy80(s)	21-52
16.	-1	405	h	2127	5769	fy80(s)	21-57
17.	-1	389	p	2155	5249	fy80(s)	21-52
18.	-1	420	h	2195	5660	fy80(s)	21-56
19.	-1	411	h	2198	5612	fy80(s)	21-56
20.	-1	381	h	2199	5681	fy80(s)	21-56
21.	-1	390	p	2199	5244	fy80(s)	21-52
22.	-1	391	p	2200	5200	fy80(s)	21-52
23.	-1	385	h	2204	5706	fy80(s)	22-57
24.	-1	383	p	2220	5710	fy80(s)	22-57
25.	-1	382	h	2231	5737	fy80(s)	22-57
26.	-1	398	p	2236	5291	fy80(s)	22-52
27.	-1	393	p	2241	5100	fy80(s)	22-51
28.	-1	392	p	2246	5113	fy80(s)	22-51
29.	-1	399	p	2246	5286	fy80(s)	22-52
30.	-1	384	h	2277	5701	fy80(s)	22-57
31.	-1	410	h	2304	5802	fy80(s)	23-58
32.	-1	409	h	2321	5873	fy80(s)	23-58
33.	-1	414	h	2370	5868	fy80(s)	23-58
34.	-1	412	p	2376	5842	fy80(s)	23-58
35.	-1	413	h	2376	5842	fy80(s)	23-58
36.	-1	415	h	2378	5888	fy80(s)	23-58
37.	-1	418	h	2402	5779	fy80(s)	24-57
38.	-1	419	h	2418	5728	fy80(s)	24-57
39.	-1	380	h	2465	5770	fy80(s)	24-57
40.	-1	416	h	2468	5932	fy80(s)	24-59
41.	-1	417	h	2492	5904	fy80(s)	24-59

The Quit Command

To quit a session, the user responds to the "What next?" prompt with the "quit" command. This returns him to the geographic information system, if he entered ASIS from this system, or to the working directory from which he entered ASIS.

7 VERSION II -- PILOT SYSTEM REDESIGN

As a pilot, the Fort Hood geographic information system was intended to be revised frequently. As the system was tested and various problems and limitations became apparent, changes were made to both the analysis capabilities and to the user interface. Numerous other changes have also been planned. However, these changes are no longer being implemented on the existing version of the system. Instead, a new version is now being developed which includes all the capabilities of Version I, as well as a number of new capabilities.

Several limitations have been identified in testing sessions with the current Version I. Among these are:

1. Operations within a session need to proceed in a set sequence -- define area of interest, select data, do overlay operations. This limits operations to preselected data.
2. Working areas can be defined only by rectangles, yet the area of interest may be a data element (e.g., training areas 41-45) or a non-rectangular area (e.g., everything within 500 meters of a particular stream or road).
3. Data can be selected only *one* subcategory at a time. Often, a user may want to group subcategories (e.g., watersheds 2, 3, and 4). This can be accomplished by using the *or* operation, but it is a tedious procedure to perform each operation, one at a time.
4. Operations can only be performed one at a time. It would be desirable to string together operations in a single command line.
5. Interdependencies within the program make simple program changes complex.
6. While there is a save function in Version I, it does not save the maps and/or tables constructed during a session *unless* the session is run again. It would be useful to have the capability to save tables/maps in separate files.

A number of other limitations in Version I relate to display and analysis capabilities that have not yet been developed (e.g., zoom capabilities for video displays, distance from operations, etc.) The above list of limitations relates to functional design of the system. Version II is now being developed to address these limitations, and it is being designed so that new display and analysis capabilities can be added easily.

In Version II, each of the procedures will "stand alone." The user will work from a main option page from the start of a session. As much as possible, the command capabilities of the UNIX operating system will be used.

These capabilities allow any number of commands to be strung together, each separated by some UNIX "piping"* command. A summary of differences between Version I and Version II is provided in Table 4.

Version II is presently only in the design phase. Thus, no output is now available. Also, though many features of the system have already been determined, some features are still likely to be changed. To the user, the system will be similar to Version I, but will offer greater flexibility. One major advantage of this new version will be the ease with which new subprograms and capabilities can be added. Eventually, numerous subprograms (such as Range Placement and ASIS) will be developed. A model of a system, with numerous potential subsystems, is given in Figure 13. In this type of scheme, users would transfer freely from the main GIS, which contains the geographic database and the display and overlay analysis capabilities to these various subsystems; the subsystems provide either unique types of analysis capabilities that use the main GIS database or data subsets with tabular output capabilities. Such a system could eventually serve the wide range of land-use activities that occur on military installations.

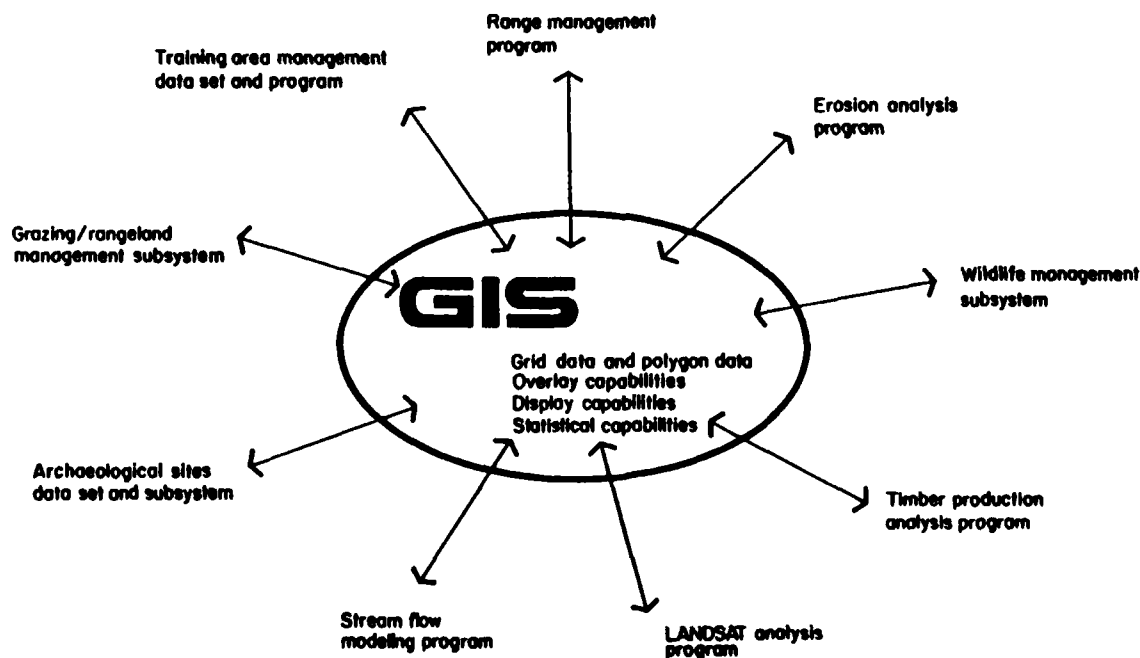


Figure 13. System and subsystem: potential programs.

* Piping commands in UNIX are simply commands that allow operations to be fit together. Thus, a user can request a series of operations to occur in a particular sequence, all in a single command line.

Table 4

Summary of Differences: Version I Vs. Version II

<u>CAPABILITY</u>	<u>VERSION I</u>	<u>VERSION II</u>
<u>Operations</u>	<p>Operations linked to various parts of the system</p> <p>Operations must be executed one at a time.</p> <p>Order of operations in fixed steps, no loop back possible, and only preselected data available for subsequent operations in main option table.</p> <p>Only overlay operations available.</p>	<p>All operations stand alone.</p> <p>Operations can be strung together.</p> <p>Order of operations can vary; user can loop back whenever desired. User also functions from main option table.</p> <p>Overlay, distance calculations, and coincidence tabulations all available.</p>
<u>Data</u>	<p>Data accessed only at one time during session.</p> <p>Data accessed only as one subcategory at a time.</p> <p>Data accessed only with binary mask where all cells have value of 1 or 0.</p> <p>Data available only in grid files.</p>	<p>New data can be accessed for each new operation or sequence of operations.</p> <p>Data subcategories can be accessed one at a time, in groups, or an entire primary category -- dump -- can be accessed.</p> <p>Data can be accessed either with binary masks or can retain unique subcategory values to each cell.*</p> <p>Data available in both grid and polygon files.</p>

*This method of retaining subcategory values for each cell can result in very complex overlay maps, but does allow some very sophisticated analysis that is not possible with only binary masks.

Table 4 (Cont'd)

<u>CAPABILITY</u>	<u>VERSION I</u>	<u>VERSION II</u>
<u>Map Output</u>	Device dependent files created for mapping. Grid cell data only can be mapped.	Device independent graphic files created -- output through device specific files. Some polygon mapping capabilities as well as grid cell capabilities.
<u>Working Area</u>	Six methods available to determine working areas -- but all must be rectangular.	Working area can be defined by any string of coordinate points, by data items (e.g., training areas 4-7) or by distance from operation around data item.*
<u>Operations</u>	Boulean overlay combinations range placement.	Boulean overlay combinations placement of any data item. Isoline map creation. Coincidence tabulations.
<u>Modifications</u>	Each modification requires substantial links between operations; several operations are affected by any change. New capabilities may require restructuring of program sequence.	Since operations can stand alone, modifications are relatively simple. Only one operation is affected at one time. New capabilities can be added easily.
<u>Save</u>	Entire session can be saved in file which consists of a string of user inputs. Tables and graphics can only be reconstructed by re-running session. (No header information on saved files.)	Output from any operations, tables or graphics can be saved or deleted. Each operation creates new files, and these files also stand alone.

*While the working area in Version II can be defined by any polygon, the actual area defined by the system will be the smallest possible box. However, this box will not limit user capabilities, and statistical tables will be built using the user-selected polygon only.

8 CONCLUSION

This report has described the development of a pilot system for a geographic information system for Fort Hood, TX. This pilot system is designed to interface with the CERL-developed ETIS and can be used to collect specific geographic information for the Fort Hood Environmental Programs Office.

The report describes:

1. The format and operation of the Fort Hood/ETIS pilot system's user programs.
2. The design of the pilot system, required hardware, and how the pilot system interfaces with ETIS.
3. The current database and the use of LandSat imagery to set up the pilot system's database grid network.
4. The ASIS subsystem, which allows the user to search site data by either geographic location or by user-specified categories.
5. Version II of the pilot systems which includes the capabilities of the old system, plus some new ones which will make the system easier to use.

APPENDIX A:

DATA CATEGORY FILES

The 30 major environmental categories in the current Fort Hood/ETIS pilot system are listed as one-word names under the "make main choices" option; however, if the user responds with a question mark, a helpfile with longer explanatory names is given. These helpfiles are also available for many of the subcategory choices, such as for soils, where the symbol option may not be familiar to the user. This appendix provides a copy of the helpfiles (where available) for the main choice options (Step 2a) and for each of the 30 categories (Step 2b).

MAIN CHOICE OPTIONS: (head)

Make main choices: What environmental variables?

- | | | |
|----------------------|-----------------------|--------------------------------|
| 1) engn geology | 11) c-country mvmt | 21) water resources |
| 2) roads-airfields | 12) firing ranges | 22) archaeological surveys |
| 3) cultural features | 13) elevation | 23) protected areas |
| 4) arch/hist sites | 14) slope | 24) ecological survey sites |
| 5) major watersheds | 15) aspect | 25) endangered species habitat |
| 6) landcover | 16) training areas | 26) noise contours |
| 7) scs soils | 17) trng. frequencies | 27) streams |
| 8) minor watersheds | 18) trng. intensities | 28) elevation (5 meters) |
| 9) vegetation | 19) training outlines | 29) experimental a |
| 10) boundaries | 20) engineering soils | 30) experimental b |

ENGINEERING GEOLOGY SUBCHOICES: (geol)

1) Make geology subchoices: What geology variables?

- | | |
|----------------------|------------------------------|
| 1 - limestone, dense | 4 - limestone, chalky |
| 2 - limestone, sandy | 5 - chalky marly shale |
| 3 - limestone, loose | 6 - unconsolidated materials |

ROADS, PIPELINES, RAILROADS, AND AIRFIELDS SUBCHOICES: (line)

2) Make line subchoices: What road and airfield variables?

- | | |
|--------------------------------------|---------------------------|
| 1 - hard surface 4 lane divided road | 9 - railroad |
| 2 - hard surface 4 lane road | 10 - railroad bridge |
| 3 - hard surface 2 lane road | 11 - pipeline or aqueduct |
| 4 - improved dirt road | 12 - pipehead |
| 5 - unimproved dirt road | 13 - tank crossing |
| 6 - major tank trail | 14 - airfield |
| 7 - minor trail | 15 - airstrip |
| 8 - bridge | 16 - landing zone |
| | 17 - drop zone |

NON-URBAN CULTURAL FEATURE SUBCHOICES: (feat)

3) Make feature subchoices: What non-urban cultural feature variables?

- | | | |
|------------------------|-------------------------|---------------------|
| 1 - Pipeline | 9 - Campground | 17 - Cemetery |
| 2 - Radio Tower | 10 - Power Substation | 18 - Water Tank |
| 3 - Staging Field | 11 - Air Control Tower | 19 - Sanitary Fill |
| 4 - Observation Post | 12 - Buildings | 20 - Gas Chamber |
| 5 - Beacon | 13 - Incinerator | 21 - Drop Zone Mast |
| 6 - Inflight Cnt. Sta. | 14 - Sewage Disp. Plant | 22 - Skeet Range |
| 7 - Ruins | 15 - Water Tower | 23 - VOR Station |
| 8 - Tower | 16 - Bleachers | |

ARCHAEOLOGICAL AND HISTORIC SITE SUBCHOICES: (site)

4) Make site subchoice: What archaeological/historical variables?

- | | |
|--------------------------|--------------------|
| 1 - Archaeological Sites | 2 - Historic Sites |
|--------------------------|--------------------|

MAJOR WATERSHED SUBCHOICES (basl)

5) Make major watershed choices: What major watershed variables?

- | | |
|-------------------|---------------------|
| 1. Leon River | 4. Belton reservoir |
| 2. Owl Creek | 5. Nolan Creek |
| 3. Cowhouse Creek | 6. Lampasas River |

LANDCOVER SUBCHOICES: (lcov)

6) Make landcover subchoices: What landcover variables?

- | | |
|-----------------|-----------------|
| 1 - other | 6 - grass |
| 2 - water | 7 - bare |
| 3 - forest | 8 - agriculture |
| 4 - shrub | 9 - disturbed |
| 5 - shrub/grass | 10 - urban |

SCS SOIL SUBCHOICES: (soil)

7) Make soils subchoices by NUMBER (not type or name): What variables?

BELL COUNTY SOILS (referenced by letter symbols)

- | | | | | |
|--------|---------|---------|---------|---------|
| 1) A1C | 8) DeB | 15) KrA | 22) LuC | 29) SnB |
| 2) Be | 9) DnB | 16) KrB | 23) LyB | 30) SPD |
| 3) Bf | 10) DPB | 17) KuB | 24) PrB | 31) SsB |
| 4) BkB | 11) Fr | 18) KVB | 25) PuD | 32) TAD |
| 5) BnE | 12) Fs | 19) LeB | 26) PVD | 33) TPF |
| 6) BRE | 13) HoA | 20) LeC | 27) REF | |
| 7) CrB | 14) HoB | 21) LgB | 28) SaB | |

CORYELL COUNTY SOILS (referenced by number symbols)

- | | | | | |
|----------|----------|----------|-----------|------------------|
| 34) 36B | 41) 8B | 48) 730 | 55) 69BC | 62) 9B |
| 35) 10B | 42) 3B | 49) 24A | 56) 55BC | 63) 64C |
| 36) 33A | 43) 11BC | 50) 83B | 57) 30BC3 | 64) nonsoil, |
| 37) 181 | 44) 601 | 51) 21B | 58) 169BC | ponds, |
| 38) U181 | 45) 530 | 52) 65B | 59) 600 | quarries, |
| 39) 105 | 46) 500 | 53) U65B | 60) 21C3 | exposed bedrock, |
| 40) 12C | 47) U500 | 54) 57C | 61) 38B | etc. |

MINOR WATERSHED SUBCHOICES: (bass)

8) Make watershed choices: What minor watershed system variables?

A. Leon

1. Cottonwood
2. Shoal Creek
3. Turnover Creek
4. North Cantonment Creek
5. Henson Creek
6. No-Name Creek

D. Belton Reservoir

44. Taylor Branch
45. Bear Creek
46. (756' Hill Creek)
47. Bull Branch
48. (Union Hill Streams)
49. Southwest Shore

B. Owl Creek

7. Misc. Owl Creek

E. Nolan Creek

50. South Nolan Creek, urban

- 8. (Demo Creek)
- 9. (2 Road Creek)
- 10. (Ruins Creek)
- 11. (Quarry Creek)
- 12. Preachers Creek

- 51. (Airfield Lake Branch)
- 52. S. Nolan Creek, part b
- 53. Hay Branch
- 54. S. Nolan Creek, part c
- 55. Heiner Lake Creek
- 56. Shay Branch
- 57. North Nolan Creek

C Cowhouse Creek

- 13. Waddle Hollow
- 14. (Misc. N7)
- 15. (Two-Year Old Creek)
- 16. (Misc. N6)
- 17. Bushy Knob Creek
- 18. (Misc. N5)
- 19. Stampede Creek
- 20. (Misc. N4)
- 21. Hargrove Creek
- 22. (Misc. N3)
- 23. Brown's Creek
- 24. (Misc. N2)
- 25. Wolf Creek
- 26. Stephensen Creek
- 27. (McBride Point Creek)
- 28. (Old East Range Creek)
- 29. (Misc. N1)
- 30. Oak Branch
- 31. (Smith Mountain Misc. S1)
- 32. (Sugar Loaf Mountain)
- 33. Riggs Run
- 34. Bull Run
- 35. (Misc. S2)
- 36. (Blackwell Mountain Creek)
- 37. House Creek
- 38. Clear Creek
- 39. (Misc. S3)
- 40. Cottonwood Creek
- 41. Table Rock Creek
- 42. (Misc. S4)
- 43. North Cowhouse Edge

F Lampasas River

- 58. Clear Creek
- 59. Gann Branch
- 60. Reese Creek
- 61. North Reese Creek

VEGETATION SUBCHOICES: (vegt)

9) Make vegetation subchoices:

- | | |
|-------------------------------------|-----------------------------------|
| 1) coniferous forest 50-100% canopy | 9) deciduous scrub 50-100% canopy |
| 2) coniferous forest 10-50% canopy | 10) deciduous scrub 10-50% canopy |
| 3) deciduous forest 50-100% canopy | 11) mixed scrub 50-100% canopy |
| 4) deciduous forest 10-40% canopy | 12) mixed scrub 10-50% canopy |
| 5) mixed forest 50-100% canopy | 13) short grass |
| 6) mixed forest 10-50% canopy | 14) tall grass |
| 7) coniferous scrub 50-100% canopy | 15) open, barren areas |
| 8) coniferous scrub 10-50% canopy | |

BOUNDARY SUBCHOICES: (bdry)

10) Make boundary subchoices: What boundary variables?

- | | |
|------------------------------|----------|
| 1 - boundary of installation | 6 - open |
| 2 - impact area boundary | 7 - open |

- 4 - major roads/highways
- 5 - railroads
- 9 - open
- 10 - open

CROSS-COUNTRY MOVEMENT SUBCHOICES: (mvm)

11) Make cross-country movement subchoices: What variables?

- 1 - level, open areas
- 2 - bottomlands
- 3 - open silty-clayey-loamy soils
- 4 - sloping brushlands
- 5 - level, juniper forest
- 6 - lightly forested
- 7 - densely forested
- 8 - steep sloped areas

RANGE SUBCHOICES: (rngs)

12) Make range subchoices: What range variables?

- 1. xm-1 tank range
- 2. dragon missile range
- 3. tow missile range

ELEVATION ZONE SUBCHOICES - 25 METER ZONES: (elev)

13) Make elevation subchoices: What elevation variables?

- 1 - < 200 meters
- 2 - 200 to 225 meters
- 3 - 226 to 250 meters
- 4 - 251 to 275 meters
- 5 - 276 to 300 meters
- 6 - 301 to 325 meters
- 7 - 326 to 350 meters
- 8 - > 350 meters

PERCENT SLOPE SUBCHOICES: (slope)

14) Make slope subchoices: What slope variables?

- 1 - 0 to 2%
- 2 - 2 to 5%
- 3 - 5 to 10%
- 4 - 10 to 15%
- 5 - 15 to 20%
- 6 - 20 to 25%
- 7 - > 25%

DIRECTION OF SLOPE - ASPECT - SUBCHOICES: (aspc)

15) Make aspect subchoices: What aspect variables?

- 1) north facing
- 2) southwest facing
- 3) east facing
- 4) southeast facing
- 5) south facing
- 6) northeast facing
- 7) west facing
- 8) northwest facing

TRAINING AREA SUBCHOICES: (tran)

16) Make training area choices: What training areas -

- | | | | | | | |
|---|----|----|----|----|----|-------------------|
| 1 | 16 | 31 | 46 | 61 | 76 | 91 |
| 2 | 17 | 32 | -- | 62 | -- | 92 |
| 3 | 18 | 33 | -- | 63 | -- | 93 |
| 4 | 19 | 34 | -- | 64 | -- | 94 (duded impact) |

5	--	35	--	65	80	95 (cantonment)
6	21	36	51	66	81	
7	22	--	52	--	82	
8	23	--	53	--	83	
--	24	--	54	--	84	
--	25	--	--	--	--	
11	26	41	--	71	--	
12	27	42	--	72	--	
13	--	43	--	73	--	
14	--	44	--	74	89	
15	30	45	--	75	90	

TRAINING AREAS - FREQUENCY OF USAGE SUBCHOICES: (trfq)

17) Make training frequency subchoices:

cat	#	training frequency/days per year
1	:	0 events per year
2	:	< 100 events per year
3	:	100 to 200 events per year
4	:	200 to 300 events per year
5	:	> 300 events per year

TRAINING AREAS - INTENSITY OF USAGE SUBCHOICES: (trin)

18) Make training intensity subchoices:

cat	#	intensity type
1	:	no maneuver usage
2	:	light
3	:	moderate
4	:	heavy

OUTLINE OF TRAINING AREAS SUBCHOICE: (trot)

19) Make training outline subchoices: What variables?

- 1 - training area boundaries

ENGINEERING SOIL SUBCHOICES: (enso)

20) Make engineering soils choices: What variables?

- | | |
|-------------------|---------------------|
| 1. fine, deep | 4. coarse, deep |
| 2. fine, moderate | 5. coarse, moderate |
| 3. fine, shallow | 6. coarse, shallow |

WATER RESOURCE SUBCHOICES - GROUNDWATER AND SURFACE WATER (wtrs)

21) Make water resource choices: What water resource variables?

- 1 - Ground water: fresh water, plentiful
- 2 - Ground water: fresh water, scarce or lacking
- 3 - Surface water: perennial, enormous

- 5 - Surface water: perennial, large
- 6 - Surface water: perennial, moderate
- 7 - Surface water: seasonal, very large
- 8 - Surface water: seasonal, large
- 9 - Surface water: seasonal, moderate
- 10 - Surface water: scarce, small

AREAS SURVEYED FOR ARCHAEOLOGICAL AND HISTORIC SITES SUBCHOICES: (arsv)

22) Make archeological survey subchoices: What survey variables?

- 1. FY 78
- 2. FY 79
- 3. FY 80 (Spring)
- 4. FY 80 (Fall)
- 5. FY 81

PROTECTED AREAS SUBCHOICES: (arpa)

23) Make protected areas subchoice:

- 1. Protected sites

ECOLOGICAL SAMPLING SITE SUBCHOICES: (ecss)

24) Make ecological sampling site subchoices: What site variables?

- 1. aquatic sampling stations
- 2. vegetation sampling stations
- 3. animal sampling stations
- 4. tracked vehicle study sites
- 5. road cruise bird census

ENDANGERED OR RARE SPECIES HABITAT SUBCHOICES: (ends)

25) Make endangered species choices: What endangered species?

- 1. golden-cheeked warbler
- 2. bigtooth maple
- 3. both warble and maple

ZONES OF NOISE TOLERANCE SUBCHOICES: (nois)

26) Make noise zone subchoices: Which zones?

Zone 1 - Acceptable for noise sensitive land uses

Zone 2 - Normally unacceptable for noise sensitive land uses except with noise abatement provisions

Zone 3 - Normally unacceptable except with extraordinary noise abatement provisions

Zone 4 - Unacceptable for noise sensitive land uses

STREAMS SUBCHOICE: (stms)

27) Make streams subchoice:

- 1. streams

ELEVATION ZONES - 5 METER INTERVAL - SUBCHOICES: (elfe)

28) Make 5 meter elevation interval subchoices: What intervals?

1) 150-4 m	11) 200-4 m	21) 250-4 m	31) 300-4 m	41) 350-4 m
2) 155-9 m	12) 205-9 m	32) 255-9 m	32) 305-9 m	42) 355-9 m
3) 160-5 m	13) 210-4 m	33) 260-4 m	33) 310-4 m	43) 360-4 m
4) 165-9 m	14) 215-9 m	34) 265-9 m	34) 315-9 m	44) 365-9 m
5) 170-4 m	15) 220-4 m	35) 270-4 m	35) 320-4 m	45) 370-4 m
6) 175-9 m	16) 225-9 m	36) 275-9 m	36) 325-9 m	46) 375-9 m
7) 180-4 m	17) 230-4 m	37) 280-4 m	37) 330-4 m	47) 380-4 m
8) 185-9 m	18) 235-9 m	38) 285-9 m	38) 335-9 m	48) 385-9 m
9) 190-4 m	19) 240-4 m	39) 290-4 m	39) 340-4 m	49) 390-4 m
10) 195-9 m	20) 245-9 m	40) 295-9 m	40) 345-9 m	50) 395-9 m

EXPERIMENTAL A - TEMPORARY DATA - SUBCHOICE (xpra)

29) Make xpra choice (currently only one):

1 - Proposed vegetation clearing area

EXPERIMENTAL B - TEMPORARY DATA - SUBCHOICE: (xprb)

30) Make xprb subchoices (currently three east side assessment areas):

- 2 - Area 2 (around Cowhouse Creek)
- 3 - Area 3 (Upland between Taylor and Bear Creeks)
- 4 - Area 4 (Owl Creek and Owl Mountains area)

APPENDIX B:

DATA HELPFILES

Following are the main choice categories (Step 2a) and the subcategories for each of the 30 categories (Step 2b).

TEXT OF HELP FILES

MAIN CATEGORY HELP

Make main choices: What environmental variables?

- 1 Engineering geology, from Terrain Analysis (T.A.).
- 2 Lines of communication (roads, pipelines,, airfields, etc.), from T.A.
- 3 Non-urban cultural features (towers, cemeteries, etc.) from T.A.
- 4 Archaeological and historical sites, from Ft. Hood Archaeologist.
- 5 Major watershed drainage basins, derived from topographic boundaries.
- 6 Land surface cover (grass, forest, water, urban) from LandSat, June, 1979.
- 7 Detailed soil survey mapping units, from Soil Conservation Service.
- 8 Minor watershed drainage basins, derived from topographic boundaries.
- 9 Categories of vegetation (type and density of cover), from T.A.
- 10 Installation boundary, political boundaries, roads, railroads & other major linear features, from 'Fort Hood Military Reservation Special' map.
- 11 Evaluation of terrain for cross-country movement, from T.A.
- 12 Firing ranges, for placement on various points in the data base.
(placement feature in subprogram outside this)
- 13 Zones of surface elevation (25 meters) above sea level, from DMA tapes.
- 14 Degrees of slope of terrain surface, from DMA tapes.
- 15 Direction of slope of terrain surface, from DMA tapes.
- 16 Training areas, from Ft. Hood training area map.
- 17 Categories of frequency of use of training areas, from 1980 training data.
- 18 Categories of intensity of use of training areas, from 1980 training data.
- 19 Outlines of training areas, from Ft. Hood training area map.
- 20 Engineering properties of soils, from T.A.
- 21 Resources of ground water and surface water, from T.A.
- 22 Archaeological survey areas, from Ft. Hood archaeologist.
- 23 Protected sites, from Ft. Hood archaeologist.
- 24 Ecological sampling sites, from Ecological Baseline report.
- 25 Endangered species habitat, from Ecological Baseline report.
- 26 Noise contours, from CERL Noise Team maps.
- 27 Major streams from topographic map.
- 28 Zones of surface elevation (5 meters) from DMA digital data.
- 29 Experimental A.
- 30 Experimental B.

SUBCATEGORY HELP FILES

(not all subcategory options have helpfiles, omissions are noted)

1. Make engineering geology subchoices: What variables?

- 1 DENSE HARD MASSIVE LIMESTONE

TOPOGRAPHY: Predominantly resistant caprock on mesa-like hillocks; surfaces of many topographic highs and ridges.

ROCK DESCRIPTION: Light gray, crystalline, coarse grained organic nearly pure limestone; much calcareous shell detritus and abundant chert nodules.

PHYSICAL CONSTANTS: Low to high permeability; low corrosion potential; high solubility; low plasticity; high seismic trans-mission velocity, possibly fracture controlled.
ENGINEERING EVALUATION: High foundation strength; suitable for hydrated lime, aggregate, raw material for portland cement, gas material, riprap, ballast, chemical and industrial process stone, agricultural limestone, fluxstone, and building stone.

2. SANDY HARD BEDDED LIMESTONE

TOPOGRAPHY: Bench form and scarps.
ROCK DESCRIPTION: Limestone, clay, marl, sand, limestone fine grained arenaceous, chalky to hard, with marine megafossils; interbedded with units composed of variable amounts of clay, marl, and sand, laminated dark gray.
PHYSICAL CONSTANTS: Low to moderate permeability; low to moderate corrosion potential; high solubility; low to moderate plasticity; variable seismic trans-mission velocity.
ENGINEERING EVALUATION: Moderate to high foundation strength, suitable for aggregate locally.

3. LOOSELY CEMENTED FINE-GRAINED LIMESTONE

TOPOGRAPHY: Local scarps and slightly rolling plains.
ROCK DESCRIPTION: Quartz sand, fine to very fine grained, friable, in part calcite cemented and hard; some thin interbeds of gray shale and limestone; pyrite nodules and concretions; coal smuts locally; commonly cross bedded and/or laminated; silty limestone beds, light gray to red.
PHYSICAL CONSTANTS: High permeability; low to moderate corrosion potential; low to moderate solubility; low plasticity; low to moderate seismic velocity.
ENGINEERING EVALUATION: High foundation strength; suitable for sand and gravel.

4. SOFT TO HARD CHALKY LIMESTONE

TOPOGRAPHY: Gentle to moderately steep slopes.
ROCK DESCRIPTION: Medium grained, chalky, some interbeds of calcareous shale, thin-bedded to massive, distinctly bedded to wavy bedded and nodular, light gray to white.
PHYSICAL CONSTANTS: Moderate permeability; low corrosion potential; high solubility; low plasticity; moderate to high seismic trans-mission velocity, locally fracture controlled.
ENGINEERING EVALUATION: Moderate to high foundation strength; suitable only as raw material for portland cement.

5. CHALKY MARLY SHALE

TOPOGRAPHY: Gently sloping plains.
ROCK DESCRIPTION: Blue to blackish clay limey marl and shell agglomerate; chalky, marly, nodular thick-bedded; a few hard beds of sparry calcite, shale as thin beds common in upper part.
PHYSICAL CONSTANTS: Moderate to low permeability; low to moderate corrosion potential; high solubility; low plasticity (some high); some moderate shrink-swell potential; low to moderate seismic trans-mission velocity.
ENGINEERING EVALUATION: Moderate to high foundation strength; suitable for lime, raw material for portland cement, clay for bricks and earthenware.

6. UNCONSOLIDATED SILT AND CLAY WITH SOME SAND AND GRAVEL

TOPOGRAPHY: Floodplains and terraced benches.
ROCK DESCRIPTION: Flood plain deposits, gravel, sand, silt, clay, and organic matter.
PHYSICAL CONSTANTS: High permeability; high flood potential; moderate corrosion potential; low solubility; moderate to low plasticity.

variable shrink-swell potential, low to moderate seismic transmission velocity.

ENGINEERING EVALUATION: Moderate foundation strength. Suitable for sand, gravel, fill and top soil.

2. Lines of communication - no helpfile, for more information see T.A.

3. Non-urban cultural features - no helpfile, for more information see T.A.

4. Archaeological and Historical sites - no helpfile. For more information, see Archaeological Sites Information System (ASIS).

5. Major Drainage Basins, subcategories: Helpfile -

These six drainage basins were defined from topographic boundaries evident on the 1:50,000 'Fort Hood Military Reservation Special' map. Although these watersheds include off-post lands, only on-post areas are included in this data category. The basins defined in the 'minor basins' category are subunits of these six 'major basins'.

6. Make landcover subchoices: What landcover variables?

1. Other - a small area in the southwest corner of the data base where data was lost in transfer.
2. Water - chiefly standing bodies of water; minor streams did not appear because of the low resolution of the sensing system and because the sediment load altered spectral response.
3. Forest - mainly cedar forests in the central section of Fort Hood and mesquite forests in the northern section.
4. Shrub - brush and sparse forest vegetation; healthy range land is covered by this classification.
5. Shrub/grassland - transitional area; denser vegetation than in grassland areas with less exposed soils. Soil types in these areas seem to have more organic matter.
6. Grassland - grassy areas with little or no brush or tree cover. More exposed soil in the area than shrub/grassland classification.
7. Bare areas - little or no vegetative cover; major vegetation is grasses. Extensive exposed soils. Secondary nonpaved roads and tank trails are included in this classification.
8. Agricultural - row crop vegetation, mainly outside of Fort Hood's boundaries. Areas classified as agricultural with the perimeter of the installation appear to be grassy meadows near streams, primarily in the area of Low House Creek.

- 9 Disturbed - highly impacted areas with ground cover of concrete, hard surface materials, or highly compacted bare soil. Peripheral urban areas, roads, airstrips, and extensive overgrazed range land artillery impact areas are also included.
- 10 Urban areas - extensive urban areas including Copperas Cove, Killen, Harker Heights, North Fort Hood, and the Fort Hood cantonment area. Hard surface features such as transportation routes and airstrips with these areas have been included.

7. Make soil subchoices: What soil variables?

BELL COUNTY SOILS

#	TYPE	MAPPING UNIT NAME
1	AlC	altoga silty clay, 2-5% slope
2	Be	bosque clay loam
3	Bf	bosque clay loam, frequently flooded
4	BkB	brackett clay loam, 1-3% slope
5	BnE	brackett-urban land complex, 3-12% slope
6	BRE	brackett association, rolling
7	CrB	crawford clay, 1-3% slope
8	DeB	denton silty clay, 1-3% slope
9	DnB	denton-urban land complex, 1-3% slope
10	DPB	denton association, undulating
11	Fr	frio silty clay
12	Fs	frio silty clay, frequently flooded
13	HoA	houston black clay, 0-1% slope
14	HoB	houston black clay, 1-3% slope
15	KrA	krum silty clay, 0-1% slope
16	KrB	krum silty clay, 1-3% slope
17	KuJ	krum-urban land complex, 0-3% slope
18	KVB	krum-lewisville association, undulating
19	LeB	lewisville silty clay, 1-3% slope
20	LeC	lewisville silty clay, 3-5% slope
21	LgB	lewisville-altoga complex, 2-5% slope
22	LuC	lewisville-urban land complex, 1-5% slope
23	LyB	lindy clay loam, dark subsoil variant, 0-2% slope
24	PrB	purves silty clay, 1-4% slope
25	PuD	purves-urban land complex, 1-8% slope
26	PVD	purves association, undulating
27	REF	real association, hilly
28	SaB	san saba clay, 1-3% slope
29	SnB	san saba-urban land complex, 0-3% slope
30	SPD	speck association, undulating
31	SsB	speck soils, 1-3% slope
32	TAD	tarrant association, undulating
33	TPF	tarrant-purves association, rolling

CORYELL COUNTY SOILS

#	TYPE	MAPPING UNIT NAME
34	36B	bastail loamy fine sand, 1-3% slope
35	10B	bolar clay loam, 1-3% slope
36	33A	bosque loam, occasionally flooded
37	181	brackett-topsey association, 3-8% slope, eroded (topsey)
38	U1E1	brackett-topsey-urban land complex, 3-8% slope

39	105	cho silty loam, 1-3% slope
40	12C	cranfill gravelly clay loam, 3-8% slope
41	8B	crawford silty clay, 1-3% slope
42	3B	denton silty clay, 1-3% slope
43	11BC	desan fine sand, 1-3% slope
44	601	doss-real complex, 1-5% slope
45	530	eckrant very cobbly silty clay, 1-3% slope
46	500	eckrant-rock outcrop complex, 1-3% slope
47	U500	eckrant-urban land complex, 1-3% slope
48	730	*evantilty clay, 1-3% slope (tarpley)
49	24A	frio silty clay, occasionally flooded
50	83B	krum silty clay loam, 1-3% slope
51	21B	lewisville silty clay loam, 1-3% slope
52	65B	minwells fine sandy loam, 1-3% slope
53	U65B	minwells-urban land complex, 1-3% slope
54	57C	*nuff stony silty clay, 2-6% slope (sanger stony)
55	69BC	*pancake silty clay loam, 1-4% slope (bolar)
56	55BC	patilo fine sand, 1-5% slope
57	30BC3	pedernales fine sandy loam, 1-5% slope, eroded
58	169BC	purves gravelly silty clay
59	600	real-brackett soils, 12-40% slope
60	21C3	seawillow silty clay loam, 3-5% slope
61	38B	slidell silty clay, 1-3% slope
62	9B	speck clay
63	64C	wise soil, 3-5% slope, eroded
64	-	non-topsoil, such as ponds, borrow pits, quarries, etc.

*field name of soils which are being proposed as series. In cases where these new soils are not include on the etis soil information system, use the soil listed in parenthesis (e.g. bolar) following the map unit name. These soils have similar properties to the proposed soils.

B. Make watershed choices. What minor watershed system variables?

A. Leon

1. Cottonwood
2. Shoal Creek
3. Turnover Creek
4. North Cantonment Creek
5. Henson Creek
6. No-Name Creek

D. Belton Reservoir

44. Taylor Branch
45. Bear Creek
46. (756' Hill Creek)
47. Bull Branch
48. (Union Hill Streams)
49. Southwest Shore

B. Owl Creek

7. Misc. Owl Creek
8. (Demo Creek)
9. (2 Road Creek)
10. (Ruins Creek)
11. (Quarry Creek)
12. Preachers Creek

E. Nolan Creek

50. South Nolan Creek, urban
51. (Airfield Lake Branch)
52. S. Nolan Creek, part b.
53. Hay Branch
54. S. Nolan Creek, part c.
55. Heiner Lake Creek
56. Shay Branch
57. North Nolan Creek

C. Cowhouse Creek

13. Waddle Hollow
14. (Misc. N7)
15. (Two-Year Old Creek)
16. (Misc. N6)
17. Bushy Knob Creek

F. Lampasas River

58. Clear Creek
59. Gann Branch
60. Reese Creek
61. North Reese Creek

- 18 (Misc. N5)
- 19 Stampede Creek
- 20 (Misc. N4)
- 21 Hargrove Creek
- 22 (Misc. N3)
- 23 Brown's Creek
- 24 (Misc. N2)
- 25 Wolf Creek
- 26 Stephensen Creek
- 27 (McBride Point Creek)
- 28 (Old East Range Creek)
- 29 (Misc. N1)
- 30 Oak Branch
- 31 (Smith Mountain Misc. S1)
- 32 (Sugar Loaf Mountain)
- 33 Riggs Run
- 34 Bull Run
- 35 (Misc. S2)
- 36 (Blackwell Mountain Creek)
- 37 House Creek
- 38 Clear Creek
- 39 (Misc. S3)
- 40 Cottonwood Creek
- 41 Table Rock Creek
- 42 (Misc. S4)
- 43 North Cowhouse Edge

Note This file lists all of the watersheds that have been defined and digitized for Fort Hood, Texas. Names of watersheds in parentheses are not listed on any maps, but have been invented for convenience. The file number is listed before the name of each watershed unit. Only the numbered subsystems are located in the minor basins (bass) main choice category, the lettered major watershed systems (A - F) comprise the subcategory choices (1 - 6) in the major basins (bas1) main choice category.

9 Make vegetation subchoices: What vegetation variables?

MAP UNIT	DESCRIPTION
1	Coniferous trees, mostly juniper; heights averaging 6 m; trunks usually 5 cm in diameter; spaced 2-4 m apart; 50-100% crown cover density; branches down to ground level; short grasses in some areas under trees; 75% or more of each stand composed of coniferous species.
2	Coniferous trees, principally juniper; heights averaging 4.5 m; trunks usually 3.75 cm in diameter; spaced 1-3 m apart; 10-50% crown cover density; branches down to ground level; tree spacing allows for lesser crown cover; locally clumps may include up to 12 trees and reach 50 m in circumference; short grasses generally under trees; 75% or more of each stand composed of coniferous species.
3	Deciduous trees, mainly live oak and Spanish oak; heights averaging 6.5 m, trunks usually 15 cm in

diameter, spaced approximately 3.5 m apart, 50-100% crown cover density, branches to within 2.5 m of ground level, leafless period generally mid-November through late March; 75% or more of each stand composed of one or more deciduous species.

- 4 Deciduous trees, mainly live oak, Spanish oak, willow, usually 11.25 cm in diameter; spacing approximately 2 m; 10-50% crown cover density; branches to within 1.3 m of ground level; leafless periods generally through mid-November to late March; 75% or more of each stand composed of one or more deciduous species.
- 5 Mixed coniferous and deciduous trees, primarily juniper and brush oak, heights average 5 m; trunk diameter up to 6.25 cm; spaced up to 3 m apart; 50-100% crown cover density; branches to ground level; small conifers may cover ground under deciduous trees; each stand contains roughly equal distribution of coniferous and deciduous species.
- 6 Mixed coniferous and deciduous trees, primarily juniper oak, and willow; heights average 4.5 m; trunks usually 5.5 cm in diameter; spacing less than 1 m apart; 10-50% crown cover density; branches start at ground level; each stand contains roughly equal distribution of coniferous and deciduous species.
- 7 Coniferous scrub, mainly juniper; heights averaging 3 m; trunks usually 6.25 cm in diameter; spacing approximately 1 m; 50-100% crown cover density; branches down to ground level; grasses under stands, usually less than 1 m high; 75% or more of each stand composed of coniferous species.
- 8 Coniferous scrub, mainly juniper; heights averaging 3 m; trunks usually 6.25 cm in diameter; spaced approximately 2-4 m apart; 10-50% crown cover density; branches down to ground level; grasses under stands usually less than 1 m high; 75% or more of each stand composed of coniferous species.
- 9 Deciduous scrub, principally willow, post oak, and mesquite, heights averaging 4 m; trunks usually 12.5 cm in diameter; closely spaced; 50-100% crown cover density; branches start roughly 0.5 m from ground level; leafless period generally mid-November through late March; 75% or more of each stand composed of one or more deciduous species.
- 10 Deciduous scrub, principally brush oaks, willow, and mesquite, heights averaging 4 m; trunks usually 6 cm in diameter; spaced approximately 2 m apart; 10-50% crown cover density, branches down to ground level; grasses less than 1 m high where present with deciduous scrub; leafless period generally mid-November through late March; 75% or more of each stand composed of one or more deciduous species.
- 11 Mixed coniferous and deciduous scrub, mainly juniper brush oaks, and mesquite, heights average less than 3 m; trunks usually 3.75 cm in diameter; spacing ranges from 0.5 m to 2 m, 50-100% crown cover density; branches down to ground level; small coniferous species;

occur under taller deciduous scrub, and grasses, if any, are short, each stand contains roughly equal distribution of coniferous and deciduous species

- 12 Mixed coniferous and deciduous scrub, primarily of juniper, brush oaks, willow and mesquite, heights average less than 3 m; trunks usually 3 cm in diameter; closely spaced, 10-50% crown cover density, branches down to ground level, grasses under scrub, if any, are short; each stand contains roughly equal distribution of coniferous and deciduous species
- 13 Short grasses, generally less than 1 m high, species include switch grass, Indian grass, and Canada wild rye, green in summer, brown in winter and through periods of drought, trees do not exceed 10% of ground cover.
- 14 Tall grasses, generally greater than 1 m high, species include switch grass, Indian grass, and Canada wild rye, green in summer, brown in winter and through periods of drought, trees do not exceed 10% of ground cover.
- 15 open, barren areas

- 10 boundaries - no helpfile.

- 11 Make cross-country movement subchoices: What variables?
- 1 - dominantly level, open cleared areas
 - 2 - bottomlands and flood plains of rivers and creeks
 - 3 - dominantly open, clear areas of silty, clayey, loamy soils
 - 4 - level to gently sloping areas covered in brush
 - 5 - predominantly level areas covered in juniper forest
 - 6 - lightly forested areas
 - 7 - densely forested areas
 - 8 - hillocks, cliffs, and stream banks with steep slopes

UNIT PREDICTED MOVEMENT RATINGS FOR

	TANK(M-60)		APC(M-113)		2 1/2 TRK(M-35)		1/4 TRK(M-151)		FOOT TROOPS	
	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET
1	good	fair	good	fair	fair	fair	fair	fair	good	good
2	good	no	good	no	fair	no	fair	no	good	poor
3	good	poor	good	poor	fair	no	fair	no	good	poor
4	fair	poor	fair	poor	poor	no	poor	no	fair	fair
5	poor	poor	poor	poor	no	no	no	no	fair	fair
6	fair	poor	fair	poor	poor	poor	poor	poor	fair	fair
7	no	no	no	no	no	no	no	no	fair	fair
8	poor	no	poor	no	no	no	no	no	poor	poor

- 12 Ranges - no helpfile

13 Make elevation zone subchoices. What elevation zones?

- 1 - < 200 meters, or < 656 feet
- 2 - 200 to 225 meters, or 657 to 738 feet
- 3 - 226 to 250 meters, or 739 to 820 feet
- 4 - 251 to 275 meters, or 821 to 902 feet
- 5 - 276 to 300 meters, or 903 to 984 feet
- 6 - 301 to 325 meters, or 985 to 1066 feet
- 7 - 326 to 350 meters, or 1067 to 1148 feet
- 8 - > 350 meters, or > 1148 feet

14 Slopes - no helpfile

15 Make aspect subchoices. What variables?

- 1) north facing, 337.5 to 22.5 degrees
- 2) northeast facing, 22.5 to 67.5 degrees
- 3) east facing, 67.5 to 112.5 degrees
- 4) southeast facing, 112.5 to 157.5 degrees
- 5) south facing, 157.5 to 202.5 degrees
- 6) southwest facing, 202.5 to 247.5 degrees
- 7) west facing, 247.5 to 292.5 degrees
- 8) northwest facing, 292.5 to 337.5 degrees

16 Make training area subcategory choices:

The data in this category defines the areal extent of each of the training areas at Fort Hood. The subcategory numbers correspond to the numbers assigned on the 1:75,000 'Fort Hood Military Reservation' map. These training areas are not numbered sequentially (for example, there is no number 28) yet system operations require sequential numbering of subcategories. Thus, number 28 and all other skipped numbers are listed in the table below as subcategory choices, but are listed as 'empty', containing no data.

In the table, four types of information are given for each training area: 1) training area number, 2) frequency of usage, 3) intensity of usage, & 4) type of usage. Frequency refers to the number of events that occur in this area during a year. The numbers (1 thru 5) correspond to subcategory choices in major category 17, training frequency (trfq), with 1 being the lowest usage and 5 being the highest. Intensity refers to the impact level of usage, with 1 being the least intense and 4 being the most intense. These numbers correspond to the subcategory choices in major category 18, training intensity (trin). Type refers to the predominant type of usage of each area, with dsm (dismounted) indicating some restrictions on vehicle usage, ds/mt indicating less restrictions, and mnt (mounted) indicating no vehicle use restrictions. lvfr (live fire) indicates that the predominant usage of an area is as a firing range.

Make training subchoices: What training variables?

#	freq	intens	type
1	1	1	mnt
2	2	2	mnt
3	3	3	mnt
4	4	4	mnt
5	5	5	mnt
6	1	1	mnt
7	2	2	mnt
8	3	3	mnt
9	4	4	mnt
10	5	5	mnt
11	1	1	mnt
12	2	2	mnt
13	3	3	mnt
14	4	4	mnt
15	5	5	mnt
16	1	1	mnt
17	2	2	mnt
18	3	3	mnt
19	4	4	mnt
20	5	5	mnt
21	1	1	mnt
22	2	2	mnt
23	3	3	mnt
24	4	4	mnt
25	5	5	mnt
26	1	1	mnt
27	2	2	mnt
28	3	3	mnt
29	4	4	mnt
30	5	5	mnt
31	1	1	mnt
32	2	2	mnt
33	3	3	mnt
34	4	4	mnt
35	5	5	mnt
36	1	1	mnt
37	2	2	mnt
38	3	3	mnt
39	4	4	mnt
40	5	5	mnt
41	1	1	mnt
42	2	2	mnt
43	3	3	mnt
44	4	4	mnt
45	5	5	mnt
46	1	1	mnt
47	2	2	mnt
48	3	3	mnt
49	4	4	mnt
50	5	5	mnt
51	1	1	mnt
52	2	2	mnt
53	3	3	mnt
54	4	4	mnt
55	5	5	mnt
56	1	1	mnt
57	2	2	mnt
58	3	3	mnt
59	4	4	mnt
60	5	5	mnt
61	1	1	mnt
62	2	2	mnt
63	3	3	mnt
64	4	4	mnt
65	5	5	mnt
66	1	1	mnt
67	2	2	mnt
68	3	3	mnt
69	4	4	mnt
70	5	5	mnt
71	1	1	mnt
72	2	2	mnt
73	3	3	mnt
74	4	4	mnt
75	5	5	mnt
76	1	1	mnt
77	2	2	mnt
78	3	3	mnt
79	4	4	mnt
80	5	5	mnt
81	1	1	mnt
82	2	2	mnt
83	3	3	mnt
84	4	4	mnt
85	5	5	mnt
86	1	1	mnt
87	2	2	mnt
88	3	3	mnt
89	4	4	mnt
90	5	5	mnt
91	1	1	mnt
92	2	2	mnt
93	3	3	mnt
94	4	4	mnt
95	5	5	mnt
96	1	1	mnt
97	2	2	mnt
98	3	3	mnt
99	4	4	mnt
100	5	5	mnt

1	3	3	dsm	4	4	3	dsm
3	3	3	dsm	6	3	3	mtn
5	4	3	dsm	8	3	3	mtn
7	4	3	dsm	10	1	1	empty
9	1	1	empty	12	4	3	ds/mt
11	4	3	ds/mt	14	4	2	ds/mt
13	4	3	ds/mt	16	4	3	ds/mt
15	4	3	ds/mt	18	3	3	ds/mt
17	2	3	ds/mt	20	1	1	empty
19	2	3	ds/mt	22	2	2	mnt
21	2	2	mnt	24	2	2	mnt
23	2	2	mnt	26	3	2	mnt
25	3	2	mnt	28	1	1	empty
27	3	2	mnt	30	3	3	mnt
29	1	1	empty	32	3	4	mnt
31	3	4	mnt	34	5	4	mnt
33	5	4	mnt				
# | freq. | intens. | type				# | freq. | intens. | type			
35	5	4	mnt	36	5	4	mnt
37	1	1	empty	38	1	1	empty
39	1	1	empty	40	1	1	empty
41	4	4	mnt	42	5	4	mnt
43	5	4	mnt	44	5	4	mnt
45	5	4	mnt	46	5	4	mnt
47	1	1	empty	48	1	1	empty
49	1	1	empty	50	1	1	empty
51	4	4	mnt	52	4	3	mnt
53	4	4	mnt	54	2	3	ds/mt
55	1	1	empty	56	1	1	empty
57	1	1	empty	58	1	1	empty
59	1	1	empty	60	1	1	empty
61	1	1	lvfr	62	1	1	lvfr
63	1	1	lvfr	64	1	1	lvfr
65	1	1	lvfr	66	1	1	lvfr
67	1	1	empty	68	1	1	empty
69	1	1	empty	70	1	1	empty
# | freq. | intens. | type				# | freq. | intens. | type			
71	3	2	ds/mt	72	4	2	ds/mt
73	4	2	ds/mt	74	2	2	lvfr/mt
75	2	2	lvfr/mt	76	2	2	lvfr/mt
77	1	1	empty	78	1	1	empty
79	1	1	empty	80	1	1	lvfr
81	1	1	lvfr	82	1	1	lvfr
83	1	1	lvfr	84	1	1	lvfr
85	1	1	empty	86	1	1	empty
87	1	1	empty	88	1	1	empty
89	1	1	lvfr	90	1	1	lvfr
91	1	1	lvfr	92	1	1	lvfr
93	1	1	lvfr	94	impact area		
95	cantonment and airfields						

17 Make training frequency subchoices:

cat # training frequency/days per year

-
- | | | |
|---|---|----------------------------|
| 1 | : | 0 events per year |
| 2 | : | < 100 events per year |
| 3 | : | 100 to 200 events per year |
| 4 | : | 200 to 300 events per year |
| 5 | : | > 300 events per year |

Training frequency subcategory choices: Helpfile -

These five subcategory choices for frequency of training use were determined from 1980 training and range use data. Counts were made of the training maneuver events during this year occurring on each of the numbered areas on the post. Only training maneuver usage was considered, not range usage. To create these subcategories, it was assumed that 1980 was a typical year in terms of level of usage, but it may be advisable to check data from other years against this 1980 data.

18 Make training intensity subcategories choices:

These four subcategory choices for intensity of training use were determined from 1980 training and range use data. Only maneuver events were considered in establishing these categories, firing range use data was excluded. The different intensity category assignments for each training area were based on several criteria. First, each maneuver event was classified light, moderate or heavy, depending on 1) type of event (e.g., a mechanized infantry exercise was considered heavy, while a compass orientation course was considered light) and 2) the size of unit conducting the exercise (some exercises, involving only squads or platoons, were considered less intense than the same type of exercise involving companies or brigades). The proportion of light, moderate and heavy events occurring on each training area, as well as the total number of events, were then used to classify each training area according to the following:

- | | |
|---------------|-----------------------------------------------------------------------------------------------------|
| subcategory 1 | no maneuver usage |
| subcategory 2 | > 20% light & < 100 events/year, or
< 25 events/year |
| subcategory 3 | between 2 and 4 |
| subcategory 4 | 30% or more heavy and > 100 events/year, or
> 50% heavy, or
> 25% heavy and > 200 events/year |

19 Training Area Boundaries - no helpfile.

20 Make engineering soil choices: What variables?

Fine-Grained Soils:

- 1 - Silty and plastic clays, mainly on floodplains; deep to very deep*
- 2 - Silty clays on level to sloping uplands; moderately deep
- 3 - Plastic clays generally overlying sandy clays on rolling to hilly uplands; shallow

Coarse-Grained and Fine-Grained Soils:

- 4 - Plastic clays overlying silty sands mainly on floodplain and low terraces, deep to very deep
- 5 - Clayey gravel, clayey sands and plastic clay mainly on dissected uplands, moderately deep
- 6 - Clayey gravels with cobbles mainly on ridge slope, shallow

* Notes: Very deep - > 6 meters
 Deep - 2-6 meters
 Moderately deep - 0.6-2 meters
 Shallow - < 0.6 meters

21 Make water resource choices: What water resource variables?

- 1 - Ground water: fresh water, plentiful
- 2 - Ground water: fresh water, scarce or lacking
- 3 - Surface water: perennially plentiful, enormous
- 4 - Surface water: perennially plentiful, very large
- 5 - Surface water: perennially plentiful, large
- 6 - Surface water: perennially plentiful, moderate
- 7 - Surface water: seasonally plentiful, very large
- 8 - Surface water: seasonally plentiful, large
- 9 - Surface water: seasonally plentiful, moderate
- 10 - Surface water: seasonal, scarce, small

Definition of Quantities:

Volume Terms	Liters Per Minute (lpm)	Gallons Per Day (gpd)
Enormous	>40,000	>15,000,000
Very large	4,000 to 40,000	1,500,000 to 15,000,000
Large	400 to 4000	150,000 to 1,500,000
Moderate	40 to 400	15,000 to 150,000
Small	4 to 40	1,500 to 15,000

Note: For further detail see pages 15 through 19 of the Terrain Analysis

22 Archaeological Survey Areas - no helpfile

23 Protected Sites - no helpfile

24 Ecological sampling sites - no helpfile, see Ecological Baseline Report

25 Endangered Species Habitat - no helpfile, see Ecological Baseline Report

26 Make noise impulsive average day/night sound level choices

Zone 1 - Less than 62 decibels
Zone 2 - 62 to 65 decibels
Zone 3 - 66 to 70 decibels
Zone 4 - Greater than 70 decibels

27 Streams - no helpfile.

28 Elevation, 5 meter zones - no helpfile.

29 Experimental A - temporary data, no permanent helpfile.

30 Experimental B - temporary data, no permanent helpfile.

APPENDIX C:

EXAMPLE SESSION

This appendix provides an example FHIS session, which includes both user inputs and system responses. In this session, an analysis of land use conflicts is made in a region of the installation for which a usage upgrade has been proposed.

Usage Procedure

After the user logs into the computer, he goes to the appropriate directory to enter the information system. Once in the system, he answers the three questions regarding the system mode of operation during this session: no noise protection, nonverbose mode, and nonvideo displays.

Next, he selects a method to define his working area -- in this case, UTM coordinates. After the user enters corner coordinates, the system provides a table with working area data. At this point, he can reject or accept this working area.

After accepting the working area, the user is now ready to select his data. In this example, he selected the nonverbose mode, but would like to see a list of all major categories. To signal the system to print this list, the user hits the carriage return three times, and the list is displayed. Again, after both primary and secondary choices are made, the user can accept or reject these choices.

Once the secondary choices are made, the system creates a mask (map layer) for each of the secondary choice items and then assembles a table. At this point, the user selects pairs of items from the data table on which to perform overlay operations. Each operation creates a new mask and adds an item to the data table until the original list of 13 items grows to 24 items.

At this point, the analysis is essentially complete, and the user requests that the statistics table be printed. Then he makes one more mask, including the UTM coordinates, to provide additional references for the maps that are subsequently requested.

The two maps printed with this example are the worst-case graphics. When no other mapping device is available, the nondevice-specific hardcopy maps can be requested. The only advantage of this type of map is that when the "or" operator is used to overlay map layers, the map symbol for each layer is retained. Thus, these maps have numerous symbols which represent various map layers.

In the two maps printed with this example, the only difference is the scale. In the first map, the row and scale factors are left in the default mode, but the result is a very small map. However, only whole numbers can be used to change row and scale factors, so producing a map with a larger scale

results in a product with a distorted horizontal/vertical relationship. Maps with accurate proportions and with varying scale factors can be printed on dot matrix printers, as in Figure 8.

Analysis

Before this session was begun, the user created a new map layer by digitizing the boundaries of the three areas proposed for a training usage upgrade. In the example, this new layer is called experimental B, and the three subcategories are called slot 2, slot 3, and slot 4.

After creating this new map layer, the user examined the existing layers for landscape characteristics that would conflict with the proposed training upgrade, such as endangered species habitat, steep slopes, and the presence of historic or prehistoric sites. These data types were then chosen for the analysis session.

In the analysis, a series of "or" overlay operations was performed to identify cells in any of these map layers that were classified with some conflicting landscape characteristic. Thus, cells with either steep slopes or golden-cheeked warbler habitat were identified with a value of "1" in the newly created map layer.

Item 21 in the user table represents the completion of these various "or" operations. To create this map layer, seven separate overlay operations were performed. At this point, the "and" operator was used to identify cells that were both in Assessment Area 2, 3, or 4 and represented some land use conflict. The result of these three "and" overlay operations are given in items 22, 23, and 24.

From these separate overlays, the amount and percentage of land for which usage conflicts occur can be determined for each assessment area. Within area 2, serious land use conflicts occur on 14.5 km², or 37.5 percent of the total area. Within area 3, conflicts occur on 20.17 km², or 51.2 percent of the total area. In area 4, conflicts occur on 15.22 km², or 48.1 percent of the total area. For the total of the three assessment areas, an average of 45.5 percent of the land has severe land use limitation.

In much of the remaining 54.5 percent of this area, there are land use management problems relating to limiting soil properties, mature and dense vegetation stands, areas already denuded by military use, and areas with slopes between 5 and 10 percent. Separate analysis sessions were run to examine these management problems.

U of I Computing Services Office VAX 11/780 (uicsovax)
 4.1bsd Unix /dev/ttyPO Thu Feb 3 14:03:55 1983
 Login: goran
 Password:
 Last login: Thu Feb 3 14:03:08 on tty37
 1 cd /xpr/lvw/Prog1
 3 this

Noise protection on? (yes or no): n
 Full prompting on? (yes or no): n
 Are you on a video terminal? (y or n): n

area method --> 1

lower left PK: 280460
 upper right PK: 432610

=====

Selected region has an area of 228.000 square kilometers.
 Corners: lower left PK: 280460 upper right PK: 432610
 Array coords: 1st row: 151 Nth row: 300 1st col: 246 Nth col: 397
 =====

Satisfied with selected area: y

main choices -->

main choices -->

main choices -->

Make main choices: What environmental variables?

1) engn. geology	11) c-country mvmt	21) water resources
2) roads-airfields	12) firing ranges	22) archaeological surveys
3) cultural features	13) elevation	23) protected areas
4) arch/hist. sites	14) slope	24) ecological survey sites
5) major watersheds	15) aspect	25) endangered species habitat
6) landcover	16) training areas	26) noise contours
7) scs soils	17) trng. frequencies	27) streams
8) minor watersheds	18) trng. intensities	28) elevation (5 meters)
9) vegetation	19) training outlines	29) experimental a
10) boundaries	20) engineering soils	30) experimental b

main choices --> 4 10 11 14 23 25 30

7 choices

Satisfied with primary choices: y

site choices --> 1 2

bdry choices --> 6

mvmt choices --> 8

slpe choices --> 4 5 6 7

arpa choices --> 1

ends choices --> 1

xprb choices --> 2 3 4

Satisfied with secondary choices: y

Creating mask 1.

.....
!.....
.....
.....
.....

Creating mask 2.

.....
.....
.....
.....
.....

Creating mask 3.

.....
.....
.....
.....
.....

Creating mask 4.

.....
.....
...\$ \$..
...\$..
...\$ \$..
...\$ \$..

Creating mask 5.

.....
.....
.....
.....
...%..

Creating mask 6.

.....
.....
.....
...%..
...%..
...%..

Creating mask 7.

.....
.....
.....
.....
.....

Creating mask 8.

.....
.....
.....
.....
.....

Creating mask 9

.....))

Creating mask 10.

.....

*

Creating mask 11.

.....

+

Creating mask 12.

.....

Creating mask 13.

.....

						2	
#	undw	syml	categ.	item		area km.	% undw.
1	A	!	4.01	site:	Archaeological	0.9	0.00
2	A	"	4.02	site:	Historic	0.3	0.00
3	A	#	10.06	bdry:	UTM coordinates	19.3	0.08
4	A	\$	11.08	mvmt:	steep slopes	35.9	0.16
5	A	%	14.04	slope:	10 to 15%	18.1	0.08
6	A	&	14.05	slope:	15 to 20%	7.6	0.03
7	A	'	14.06	slope:	20 to 25%	1.5	0.01
8	A	(	14.07	slope:	> 25%	0.2	0.00
9	A	)	23.01	arpa:	lmtd use areas	12.0	0.05
10	A	*	25.01	ends:	golden-cheeked warbler	18.8	0.08
11	A	+	30.02	expr B:	slot 1	38.6	0.17
12	A	,	30.03	expr B:	slot 3	39.4	0.17
13	A	-	30.04	expr B:	slot 4	31.7	0.14

MAIN OPTION --> 1

OPERATIONS --> 2

Which table entry # is mask A: 5

Which table entry # is mask B: 6

Creating mask 14.

.....

```

.....
%
%

```

#	wndw	syml	categ.	item	area km.	% wndw.
14	A	.		Either 5 | 6 OR both pres.	25.6	0.11

MAIN OPTION --> 1

OPERATIONS --> 2

Which table entry # is mask A: 7

Which table entry # is mask B: 14

Creating mask 15.

```

.....
%
%

```

#	wndw	syml	categ.	item	area km.	% wndw.
15	A	/		Either 7 | 14 OR both pres.	27.2	0.12

MAIN OPTION --> 1

OPERATIONS --> 2

Which table entry # is mask A: 8

Which table entry # is mask B: 15

Creating mask 16.

```

.....
%
%

```

#	wndw	syml	categ.	item	area km.	% wndw.
16	A	I		Either 8 | 15 OR both pres.	27.4	0.12

MAIN OPTION --> 1

OPERATIONS --> 2

Which table entry # is mask A: 4

Which table entry # is mask B: 9

Creating mask 17

```
.....
$)J
$
$ $
```

						2	
#	undw	syml	categ.	item	area km.	% undw	
17	A	J		Either 4 | 9 OR both pres.	43.0	0.19	

MAIN OPTION --> 1

OPERATIONS --> 2

Which table entry # is mask A: 10

Which table entry # is mask A: 17

Which table entry # is mask B: 10

Creating mask 18.

```
.....
$)K
$ *
$ $
```

						2	
#	undw	syml	categ.	item	area km.	% undw	
18	A	K		Either 17 | 10 OR both pres.	51.2	0.22	

MAIN OPTION --> 1

OPERATIONS --> 2

Which table entry # is mask A: 16

Which table entry # is mask B: 18

Creating mask 19

```
.....
$)K
L *
L L
```

						2	
#	undw	syml	categ.	item	area km.	% undw	
19	A	L		Either 16 | 18 OR both pres.	63.6	0.28	

MAIN OPTION --> 1

OPERATIONS --> 2

Which table entry # is mask A: 1

Which table entry # is mask B: 2

Creating mask 20.

.....
!
.....
.....
.....

2							
#	wndw	symb	categ.	item		area km.	% wndw.
20	A	M		Either 1 | 2 OR both pres.		1.2	0.01

MAIN OPTION --> 1

OPERATIONS --> 2

Which table entry # is mask A: 19

Which table entry # is mask B: 2011111111

Creating mask 21.

.....
!
...\$)K.
...L.*
...L.L..

2							
#	wndw	symb	categ.	item		area km.	% wndw.
21	A	N		Either 19 | 20 OR both pres.		64.5	0.28

MAIN OPTION --> 1

OPERATIONS --> 1

Which table entry # is mask A: 11

Which table entry # is mask B: 21

Creating mask 22.

.....
!
.....
.....
.....
0

#	wndw	syml	categ.	item	area km.	% wndw
22	A	0		Both 11 & 21 pres.	14.5	0.06

MAIN OPTION --> 1

OPERATIONS --> 1

Which table entry # is mask A: 12

Which table entry # is mask B: 21

Creating mask 23

q q
q

#	wndw	syml	categ.	item	area km.	% wndw
23	A	q		Both 12 & 21 pres.	20.2	0.09

MAIN OPTION --> 1

OPERATIONS --> 1

Which table entry # is mask A: 21

Which table entry # is mask B: 13

Creating mask 24

rrr

#	wndw	syml	categ.	item	area km.	% wndw
24	A	r		Both 21 & 13 pres.	15.2	0.07

MAIN OPTION --> 2

TABLES --> 2

Item	Net Area				percent sector	percent tot area
	sq. km	hects.	sq mi.	acres		
site Archaeological	0.93	93.0	0.36	230	0.4	0.1
site Historic	0.30	30.0	0.12	74	0.1	0.0
bdry UTM coordinates	19.29	1929.0	7.44	4768	5.5	1.1

mvm:	steep slopes	35.95	3595.0	13.86	8887	15.8	2.0
slope:	10 to 15%	18.09	1809.0	6.98	4472	7.9	1.0
slope:	15 to 20%	7.55	755.0	2.91	1866	3.3	0.4
slope:	20 to 25%	1.48	148.0	0.57	366	0.6	0.1
slope:	> 25%	0.21	21.0	0.08	52	0.1	0.0
arpa	lmtd use areas	12.00	1200.0	4.63	2966	5.3	0.7
ends	golden-cheeked wa	18.80	1880.0	7.25	4647	8.2	1.0
expr B	slot 2	38.62	3862.0	14.89	9547	16.9	2.1
expr B	slot 3	39.40	3940.0	15.19	9740	17.3	2.2
expr B	slot 4	31.67	3167.0	12.21	7829	13.9	1.7
Either 5	: 6 OR both pr	25.64	2564.0	9.89	6338	11.2	1.4
Either 7	: 14 OR both p	27.18	2718.0	10.48	6719	11.9	1.5
Either 8	: 15 OR both p	27.42	2742.0	10.57	6778	12.0	1.5
Either 4	: 9 OR both pr	42.96	4296.0	16.57	10620	18.8	2.4
Either 17	: 10 OR both	51.17	5117.0	19.73	12649	22.4	2.8
Either 16	: 18 OR both	63.64	6364.0	24.54	15732	27.9	3.5
Either 1	: 2 OR both pr	1.23	123.0	0.47	304	0.5	0.1
Either 19	: 20 OR both	64.55	6455.0	24.89	15957	28.3	3.6
Both 11 & 21	pres.	14.50	1450.0	5.59	3584	6.4	0.8
Both 12 & 21	pres.	20.17	2017.0	7.78	4986	8.8	1.1
Both 21 & 13	pres.	15.22	1522.0	5.87	3762	6.7	0.8

MAIN OPTION --> 1

OPERATIONS --> 2

Which table entry # is mask A: 3

Which table entry # is mask B: 21

Creating mask 25.

```

$)K.
L *
L L

```

#	wndw	syml	categ.	item	area km.	% wndw.
25	A	s		Either 3 : 21 OR both pres.	77.8	0.34

MAIN OPTION --> 3

GRAPHICS -->

GRAPHICS -->

GRAPHICS -->

GRAPHICS : 1) Vt100 2) Vt100 dump 3) Hardcopy 4) Ramtek

GRAPHICS --> 3

Which table entry: 25

Input desired row scale factor (currently 9): 9

Input desired col scale factor (currently 4): 4

Ft Hood, Texas Window = 77.8 sq km
One cell = 100 X 100 meters One char = 36 cells.
One ticmark every 5000 meters.

[illegible]

Item displayed is Either 3 : 21 OR both pres.. Area: 77.8 sq. km.

MAIN OPTION --> 3

GRAPHICS --> 3

Which table entry: 25
Input desired row scale factor (currently 9): 5
Input desired col scale factor (currently 4): 2
Ft. Hood, Texas Window = 77.8 sq. km.
One cell = 100 X 100 meters One char = 10 cells.
One ticmark every 5000 meters.

[illegible]


```

      #          #          $sL((%$L&##sLKLL*****  $$$  ***  s*
      #          #          $' $L$ $  #          # $' %  ***#  s$  #L**
      $L%$ #          $%&%  sL%  #          #  LL' %  #          ***L***** $s$L*
      :%%$LL$L% #          &%%&sL%$  #          #  LLLLLL&#  #          #KL**LLKLs**
      :&%  $LL$Ls$L$&$$$L%#  $L&  sLLL%  #          LL%#  $s%% %** #%%
      #          #          %sLL%L&%  $sL%%  #          '%  sL&&'&%**s***
      #          #          s$$$&%  #          %&s&&  s  $$ %  s%
      #          $$$  #  L&$$$  #          #  %LL%&%s  $$$$$$%
      #          $$ #$$$  #  $$$%  #          #  s  & %  %
      +          #          s  $$  %LL%Ls%$LLL%$L%#  #          s%  +
+-----+-----+-----+-----+-----+-----+-----+-----+

```

PK460 N

Item displayed is Either 3 : 21 OR both pres.. Area: 77.8 sq. km.

MAIN OPTION --> 5

exiting
 Save session (yes or no): y
 Specify a two digit session number: conflict
 Session being saved in file: Ses/goranconflict
 37.8u 47.8s 26:47 5% 29+405k 676+49io 32pf+0w
 4
 End time: Thu Feb 3 14:34:09 1983

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ATTN: EAFE-T 96212

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ATTN: EAFE-P 96259
ATTN: EAFE-T 96212
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ATTN: EUSA-HMC-CFC/Engr

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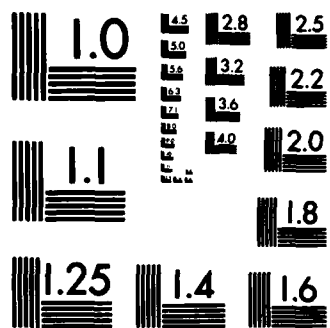
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